Science and Art Department

OF THE

COMMITTEE OF COUNCIL ON EDUCATION.

GOVERNMENT SCHOOL OF SCIENCE APPLIED TO MINING AND THE ARTS,

Museum of Irish Industry, Stephen's-green, East.

PROGRAMME

OF

EDUCATIONAL ARRANGEMENTS

FOR THE

SESSION OF 1862-1863.

Including the Introductory Lectures of the Royal Dublin Society, and of the Museum of Irish Industry, as arranged by the Committee of Lectures, under whose authority they are given.— *Vide* separate Programme.

THE SESSION WILL BE OPENED ON THE 2ND OF OCTOBER, BY AN ADDRESS FROM THE DIRECTOR.

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1862.

COMMITTEE OF COUNCIL ON EDUCATION.

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GOVERNMENT SCHOOL OF SCIENCE APPLIED TO MINING AND THE ARTS.

MUSEUM OF IRISH INDUSTRY.

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Professors.

Physics, ... WILLIAM BARKER, M.D., M.R.I.A.

Chemistry, ... WILLIAM K. SULLIVAN, PH.D., M.R.I.A.

Botany, ... WILLIAM H. HARVEY, M.D., F.R.S., M.R.I.A.

Zoology, ... J. R. KINAHAN, M.D., M.R.I.A., F.L.S.

Geology, ... J. BEETE JUKES, M.A., F.R.S., M.R.I.A. (Local Director of Geological Survey of Ireland).

Analytical and Practical Chemistry, . ROBERT GALLOWAY, F.C.S.L. (Chemist to the Museum).

Curator of the Museum.

ALPHONSE GAGES.

Assistant Chemist.

WILLIAM PLUNKETT, F.C.S.L.

Clerk and Accountant.

GEORGE PENNY.—Office, Museum of Irish Industry.

SYLLABUS OF THE COURSE OF LECTURES.

(The figures refer to the pages of the detailed Syllabus.)

PROGRAMME.

SYSTEMATIC.

The systematic courses of scientific lectures delivered in the theatre of the Museum of Irish Industry commencing with the Session of 1854–1855, may be considered as the first fully organized arrangement carried out in Dublin to provide those who are occupied in the day time with the means of employing their leisure hours in the evening in learning thoroughly the more practically useful branches of science. The success of the experiment, notwithstanding that the advantages offered could not at the outset have become generally known, has been such as to fully call for a continuation of it during the succeeding session.

But while the education of that numerous and important portion of the public will be provided for, it was proposed to extend still further the utility of those educational arrangements for the future, by establishing corresponding courses of lectures on the several departments of applied science, to be delivered during the day, and the arrangements adopted for that object have been found so successful, that they will be continued in the approaching Session, with only such slight modifications in detail as experience has proved to be desirable.

Day and Evening Classes.

In the session of 1862–1863, accordingly, there will be two distinct and independent series of courses of lectures—the one to be delivered in the day time, the other in the evening. The number of lectures in each course will be found in the detailed calendar annexed.

Place of Delivery.

In addition to the systematic courses of lectures given during the preceding years, and which were wholly delivered in the theatre of the Museum of Irish Industry, each professor gave an additional course of twelve lectures of a popular character in the theatre of the Royal Dublin Society, under the direction of the Committee of Lectures, conjointly appointed by the Government and the Royal Dublin Society. With the view of rendering those lectures of greater utility, it was proposed to bring them into connexion with the systematic courses. The joint Committee, under whose direction the arrangements for those lectures were carried out, having at once sanctioned this connexion, the first twelve lectures of each systematic course of day

lectures have been approved of by them accordingly, and will be delivered in the theatre of the Royal Dublin Society, in lieu of the popular lectures hitherto delivered there. The remaining twenty lectures of each day course will be delivered in the theatre of the Museum of Irish Industry.

Each professor has hitherto also given a course of evening popular lectures in the theatre of the Museum of Irish Industry. In future it is proposed to make these lectures part of the evening systematic courses; but in order to avoid the inconvenience which would arise of having two lectures on the same day in the same theatre, two of the evening courses will be wholly delivered in the theatre of the Royal Dublin Society. Accordingly, during the delivery of day lectures in the theatre of the Royal Dublin Society, any evening lectures which may be given during the same period will be delivered in the theatre of the Museum of Irish Industry; and when the latter theatre will be occupied during the day, the evening lectures will be given in the theatre of the Royal Dublin Society.

In this association of all the lectures of a popular character with the systematic ones, the privileges which the public has hitherto enjoyed will not be interfered with, while it is hoped that the utility of the lectures will thereby be very greatly increased.

Time and Manner of Delivery.

As a large number of persons will attend these courses whose time and attention will necessarily be more or less occupied with business, it has been thought judicious that lectures on two different subjects should not alternate as heretofore, but that each course, or division of a course, should end before a different course be commenced. This arrangement, which will prevent the continued alternation of different subjects, and consequent danger of confusion of ideas, will, it is hoped, be of equal advantage to those students who can devote their whole time to study.

The session will commence on Thursday, the 2nd of October, 1862, and end on Wednesday, 17th June, 1863.

On the 2nd of October, the Director, Sir R. Kane, will deliver an opening address at eight o'clock, P.M., in the theatre of the Museum of Irish Industry.

Day Classes—*Before Christmas.*

Zoology.—On Monday, the 6th of October, the Professor of Zoology will commence a course on Geographical and Palæontological Zoology in the theatre of the Royal Dublin Society, at four o'clock, P.M., to be continued every day, Sa-

turday excepted, until completed. This constitutes the first part of his systematic course, consisting of twelve lectures.

Physics.—On Thursday, October 23rd, the Professor of Physics will commence his course in the theatre of the Royal Dublin Society, at four o'clock, P.M., to be continued every day, Saturday excepted, until he shall have completed the first part of his course, consisting of twelve lectures.

Chemistry.—On Monday, November 10th, the Professor of Chemistry will commence a course of twelve lectures, in the theatre of the Royal Dublin Society, at four o'clock, P.M., to be continued every day, except Saturday, until completed.

Geology.—On Monday, December 1st, the Professor of Geology will commence a course of twelve lectures (being the first of his general course), in the theatre of the Royal Dublin Society, at four o'clock, P.M., to be continued every day, except Saturday, until completed.

After Christmas.

Geology.—On Monday, January 5th, 1863, the Professor of Geology will resume his course at four o'clock, P.M., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed.

Chemistry.—On Tuesday, February 17th, the Professor of Chemistry will resume his course at four o'clock, P.M., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed.

Physics.—On Monday, April 13th, the Professor of Physics will resume his course at four o'clock, P.M., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed.

Botany.—The Professor of Botany will commence a course of lectures on Botany, on Thursday, May 14th, at 4 o'clock, P.M., in the theatre of the Royal Dublin Society, to be continued at the same place and hour on every day of the week, except Saturday, until the course is completed.

EVENING CLASSES—*Before Christmas*

Zoology.—The Professor of Zoology will commence a course of lectures on Zoological Classification and Physiology, on Monday, November 24th, at eight o'clock, P.M., in the theatre of the Museum of Irish Industry, and will continue at the same place and hour, on every day of the week, except Saturday. This completes the systematic course.

Geology.—The Professor of Geology will commence a course of twelve lectures on Physical Geography, on Monday, November 3rd, at eight o'clock, P.M., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day of the week, except Saturday, until the course be completed.

Chemistry.—The Professor of Chemistry will commence a course of lectures on Chemistry, on Monday, October 13th, at eight o'clock, P.M., in the theatre of the Museum of Irish Industry, to be continued, at the same place and hour, on every day of the week, except Saturday, until the course be completed.

After Christmas.

Physics.—The Professor of Physics will commence the first part of his course of evening lectures on Monday, January 5th, 1862, at eight o'clock, P.M., in the theatre of the Royal Dublin Society, and will continue, at the same place and hour, on every day of the week except Saturday, until the course be completed.

Botany.—The Professor of Botany will commence his course of lectures, at eight o'clock, P.M., on Wednesday, May 6th, in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day of the week, except Saturday, until completed.

A table of the days, hours, and places of delivery of the lectures, arranged as an almanac for each month, is appended, and will serve as a useful guide to students and the public generally.

REGISTRATION AND FEES.

No person will be considered eligible to compete for certificates or prizes, unless he shall have registered himself as a student and paid the requisite fees.

The office for registration is at the Museum of Irish Industry, where Mr. Penny will receive the names of all who are desirous of entering as students, and supply them with admission tickets.

Students may register for one or more of the courses, and compete for the special certificates and prizes allotted to each course, but can only become eligible for a General Certificate by registration for and attendance upon a course in each of the four subjects, either in the day or evening classes.

As the first twelve lectures of the day classes will represent the popular lectures hitherto delivered at the Royal Dublin Society, under the direction of the Committee of Lectures, they will be free to the public; for the remaining twenty lectures a fee of 3*s*. 6*d*. will be charged for the lec-

tures on chemistry, on natural philosophy, or geology, and 2*s*. for the lectures on zoology or on botany.

The first twelve lectures of the evening classes, representing the popular evening lectures hitherto delivered in the Museum of Irish Industry, under the direction of the Committee of Lectures, will likewise be free to the public; for the remaining eight a fee of 6*d*. will be charged, wherever they may be delivered.

Examinations.

At the close of the courses of systematic lectures of each professor, a Special examination of the registered students will be held by the lecturer, and the names of those who pass it will be arranged and published in order of merit.

At the close of the session a General Examination will be held in all of the subjects lectured on in the school, open to all those who shall have attended one course at least in each of the five subjects, in either the day or evening classes, and passed *one* at least of the Special examinations, either of that or of the previous session.

Students who have passed a Special examination, but not gained a prize, will be admitted to one more Special examination in the same subject, after which they will not be deemed eligible for a prize in it.

Students who have once passed a General Examination will not be admitted to any further examination of any kind.

Practical Instruction.

Chemistry.—In the chemical laboratory practical instruction will be given, during the session, in qualitative and quantitative analysis, and in the method of performing chemical researches. (The reader is referred to the Programme of Laboratory Arrangements, page 105, for a more detailed account.)

Botany.—The Professor of Botany proposes to hold a series of excursions for herborizations on days to be subsequently decided upon, of which due notice will be given to the classes by the professor.

Zoology.—The Professor of Zoology will hold excursions for the purpose of field study, of which due notice will be given to the class.

Lectures.

On Monday, November 24th, the Professor of Zoology will commence a course of twenty lectures on Structure and Physiology (being the third of the general zoological courses), at the Museum of Irish Industry at 3 P.M., in the

Zoological Class-room. The lectures will be continued till completed on every week-day except Saturday.

On Monday, January 5th, 1863, the Professor of Zoology will commence the concluding course in General Zoology, on Histology, and the Microscope, at 7 P.M., in the Zoological Class-room, in the Museum of Irish Industry, and will continue the subject at the same hour and place on Mondays, Tuesdays, Wednesdays, and Thursdays until completed.

For further information, *vide* pages 108, 109.

Geology.—The Professor of Geology will also make some excursions, for the purpose of giving such students as can accompany him practical lessons upon the method of observation in the field. The Professor will arrange with his classes as to the time of his holding these excursions.

Certificates and Prizes.

Two kinds of certificates will be granted—

Pass Certificates will be given to such as pass each Special examination, whether Systematic or Practical.

General Certificates, stating the proficiency obtained in the several branches of study, signed by all the Professors, and countersigned by the Director, will be given to those who shall have passed all the Class Examinations within a space of two years.

The value of certificates testifying to a knowledge of the more practically useful branches of science will become daily more and more recognised; and already a very large number of the leading manufacturers of the United Kingdom have agreed to accept similar certificates as one of the highest testimonials which can be presented by persons seeking employment in their establishments. Every student should, therefore, strive to win such a certificate.

Prizes will be awarded to the first three names in the list of those who pass each examination, provided sufficient proficiency be shown.

These prizes will consist either of money, or of books stamped with the mark of the institution, or partly one and partly the other, at the option of the student.

The value of the prizes will be—

Systematic Courses.

For the Special examinations,
First prize, £5; second prize, £2; third prize, £1.

Practical Courses.

The sum of £8 and two free admissions will be awarded in prizes to the evening classes of Practical Chemistry, as will be arranged after the classes are formed.

Prizes may be awarded in the class of Practical Zoology, as will be arranged on the formation of the class. *See* page 108.

No person having gained a Special prize will be deemed eligible again for a prize in the same subject.

The certificates will be awarded and the prizes conferred at a public meeting of the Institution, as will be arranged by the authorities of the Science and Art Department.

Evening Admission to the Galleries and Library of the Museum of Irish Industry.

Nothing tends so materially to familiarize the mind with scientific names, and to impress upon the memory the information acquired from books and lectures, as the examination of the objects themselves, the study of whose properties or forms constitutes the basis of the experimental and observation sciences. This is especially true of natural history and geology, and, perhaps in an equal degree, of chemistry in its applications to industry. The collections illustrative of chemical compounds and chemical manufactures, and of geology, now in the galleries of the Museum of Irish Industry, are sufficiently extensive to be useful in this way. With a view, accordingly, of making them contribute as far as possible to public education generally, and especially to the development of the system of instruction established in the School of Arts and Manufactures, the galleries will be lighted with gas, and opened to the public on all the evenings of lecture during the session, and on such other evenings as shall be arranged, of which due public notice will be given.

With a view of facilitating the studies of those students who are occupied during the day, and cannot therefore visit any public library, access will be allowed to the library of the Museum of Irish Industry, which is provided with a number of suitable books in each department of science, selected by the respective professors. This library will be opened during the session at times and hours to be hereafter determined. The privilege of reading in this library must necessarily be exclusively confined to those students who desire to qualify for certificates by attendance upon all the courses, in one or other class, given during the session.

Recommendations to Students about their Preliminary Studies.

The best preparations for the study of any branch of science is the study of mathematics, not merely because it is itself the first of the fundamental sciences, and in some cases the most powerful and indispensable instrument of research,

but even as a mere mental exercise. A familiarity with mathematical reasoning usually gives more definiteness and exactness of ideas, and leads the student to disregard the usual vague and loose statements which the untrained mind is apt to accept as science, while it teaches him to set most value in the experimental sciences upon numerical relations, not only as the most important in a theoretical point of view, but also in a practical one.

A knowledge of the four principal operations of arithmetic (addition, subtraction, multiplication, and division), vulgar and decimal fractions, the extraction of square and cube roots, ratio and proportion, and the elements of geometry, will enable a person to acquire a very good knowledge of experimental physics and chemistry. Without this amount of knowledge, at least, many important points in both branches of science must be unintelligible, or at best must be very imperfectly understood.

And as it is impossible to have an accurate knowledge of animal and vegetable physiology, which are the basis of the other divisions of natural history, or of geology, without some previous knowledge of experimental physics and chemistry, this amount of elementary mathematics is equally necessary to the student who desires to pursue in an especial manner those branches of science.

There is one very simple truth which it is very desirable should be impressed upon the minds of students—namely, that in order to apply science to industry, it must be first learned; and that, consequently, the impression which commonly prevails, and which some, who ought not to do so, have helped to foster, that there is a kind of inferior science adapted for practical persons, is perfectly erroneous. Indeed, no one requires to know science so thoroughly as he who intends to apply it in his business. The kind of science which is capable of being applied to industry with advantage must therefore be, in reality, of a far higher character than what is required as an element of general education.

Persons who intend to register themselves as students of the School, with a view of applying the knowledge of science which they may acquire in some of the various branches of industry, such as mining, the construction of machines, textile and chemical manufactures, agriculture, &c., will do well to remember, that although the amount of mathematics mentioned above will enable them to acquire a vast amount of information in the subjects taught during the session, it will be far from sufficient to enable them to apply it with profit in industry. Such questions as the strength of materials; the flow of water, steam, or gas, through pipes; the

construction of water-wheels and turbines; or the theory of machines in general, and similar questions which perpetually present themselves to the manufacturer, require for their solution a considerable amount of mathematical knowledge.

While it is to be hoped that no one will be discouraged from joining the classes of the ensuing session because they may not have previously studied the elementary mathematics, all who desire to acquire that accurate knowledge which alone is practically useful, should endeavour, either by self-instruction, or through the many facilities which exist for the purpose, to learn, at least, the most indispensable branches of elementary mathematics.

With a view of pointing out the extent of mathematics which it would be desirable that students who intend to become mining engineers, ship-builders, machinists, or managers of factories generally, should possess, before commencing the study of the experimental sciences, and of guiding those who desire, in the mean time, or in future years, to reach this standard of preparation by self-instruction or otherwise, the following syllabus of a course of elementary mathematics is added. Such a course would take the student as far as the calculus, and would enable him to understand all lectures upon mechanics, statics, and dynamics, and make use of the generality of text books upon those subjects. Before entering upon the course of study the student would derive great advantage from the reading of some work on logic of the character of the "System of Logic," by J. S. Mill, or Thompson's "Laws of Thought."

Syllabus of a Course of Elementary Mathematics, preparatory to the Study of the Physical and Natural Sciences, and of their application to Industry.

Arithmetic.—Numeration and notation. *Integral Numbers:*—The four principal operations of arithmetic with whole numbers (addition, subtraction, multiplication, and division). Determination of the greatest common divisor of two or more numbers, and the simplest common multiple. *Fractions:*—1° *Vulgar Fractions*—Formation of vulgar fractions; the four principal operations with them. 2° *Decimal Fractions*—Distinction between vulgar and decimal fractions; the four principal operations with decimal fractions; conversion of vulgar fractions into decimal fractions, and the reverse.

Extraction of roots.

Ratio and proportion.

Geometry.—1° *Plane Geometry*—Properties of lines and angles. Properties of triangles and quadrilateral figures. Ratios and proportions. Geometry of the circle, and the measure of angles. Regular polygons, and the measure of the circle.

2° *Solid Geometry.*—Intersection of planes—solid angles. Solids bounded by planes :—The parallelopiped ; polyhedrons. The three round bodies:—The cylinder, cone, and sphere. Properties of the sphere and spherical triangles.

Or the whole of Euclid's Elements of Geometry.

Elements of Geometrical Analysis.

Algebra.—The four rules with monomes and polynomes. Simple powers and roots. The greatest common measure, and the least common multiple. Fractions.

Equations of the first degree, including one unknown quantity. Equations of the first degree, including two or more unknown quantities.

Arithmetical progression. Geometrical progression. Permutations and combinations. Series and indeterminate coefficients. Binomial theorem.

Equations of the second degree. Exponential equations. Exponential and logarithmic series. Use of logarithms.

Classification of algebraical expressions and consequences.

Relation between number and magnitude.

Trigonometry.—Definitions. Relations of trigonometrical lines. Relation between sines, cosines, &c., of sums, and differences of angles. Solution of plane triangles.

Elements of Analytical Geometry.—Application of algebra to the theory of Curves :—Straight lines ; transformation of co-ordinates ; lines of the second order, or the conic sections. Application of algebra to the theory of Surfaces :—The straight line in space. The plane. The sphere, cylinder, and cone. Surfaces of revolution. Surfaces of the second order.

Descriptive Geometry.—Projection of lines, of planes, and of curved surfaces. Intersections of lines, planes, and surfaces. Applications to cylindrical, conical, and spherical surfaces. Skew surfaces. Theory of ordinary perspective and of isometrical perspective. Theory of shadows.

R. K.

DETAILED SYLLABUS.

[The object in view in drawing up this Syllabus on so much more enlarged a plan than that usually followed, is to provide the student with such an index to each branch of science, that however differently the text-book which he employs may be arranged, he may still be able to follow in his reading the order of subjects adopted by the professor. It is also intended to keep the sequence of subjects before the student's mind and familiarize him with the technical names, especially those employed in classification, in Natural History, and Geology, to the students of which it will prove, it is to be hoped, a very great boon.]

PHYSICS.

Professor, WILLIAM BARKER, M.D.

OBJECTS OF PHYSICAL SCIENCE.—Definition of forces acting on Matter. Molecular and Physical forces—Ponderable and imponderable substances.

PROPERTIES OF PONDERABLE MATTER.

PHYSICS OF PONDERABLE MATTER.—General properties of Matter — Extension — Divisibility — Mathematical proof of Infinite Divisibility—Practical limits—Illustrations of extreme Divisibility afforded by Chemistry and by Mechanical and other means—Impenetrability—Porosity—Compressibility—Elasticity—Relative Elasticity of different forms of Matter—Tenacity — Measures of Cohesive Force — Importance of knowledge of force of Cohesive Attraction in the Arts — Adhesion—Capillary Attraction—Endosmose and Exosmose —Gravity — Its action on Matter of all Forms — Specific Gravity—Inertia—Laws of Inertia—Special properties of Matter—Elasticity and Hardness—Ductility—Malleability.

STATICS.

Forces exerted on Matter.—Force produces rest or motion or change of direction, on Matter in motion—Limit of force—Measurable and Immeasurable forces—Measurable forces, how expressed in quantity and direction—Composition and Resolution of Forces—Resultant of two or more forces—How expressed in quantity and direction—Parallelogram of forces—Polygon of forces—Parallel forces—Centre of Gravity—determination of its position in lines, symmetrical figures, surfaces and solids—Equilibrium—Stable or unstable.

DYNAMICS.

Forces of Matter in Motion.—Composition and Resolution of Motion—Motion absolute or relative—Resultant of two or more Motions—Curvilinear Motion—Momentum—Forces derived from Momentum—Formulæ expressive of Momentum—Application to Machinery—Laws of Action and Reaction—Effects of Collision—Effects on elastic and inelastic Matter—Centrifugal force—Consequence of Inertia—Whirling Table—Application of Centrifugal force to manufactures.

Effects of Gravity in producing motion—Motion, uniform or accelerated—Accelerated velocity—Attwood's Machine for proving laws of accelerated motion—Formulæ for expressing relations of Space, Time, and Velocity—Motion of bodies down an Inclined Plane—Motion in a Cycloidal Arc—Pendulum—Compensating Pendulum.

Theory of Machinery.—Motive powers used in Machinery, or Prime Movers—Primary sources of Motive Power—Machines do not increase power, merely alter time or direction of its application.

Simple Machines.—Lever, three species of—Conditions of Equilibrium in three species—Inclined Plane—Pulley—Balance—Wheel and Axle—Wheelwork—Screw—Hunter's Screw — Wedge — Pulleys — Compound Pulleys — Angular divergence of Cords.

Friction and Rigidity.—Different kinds of friction—Laws of friction—Friction in Lever—Inclined Plane and Wedge—Pivot friction—Friction of rolling bodies—Rigidity of Ropes and Chains.

Strength of Materials.—Dependent on forces resisting tension, pressure, or torsion—How ascertained by direct experiment—Relative strength of solids of different species—Relative strength of different forms of same material.

HYDROSTATICS AND HYDRODYNAMICS.

Properties of Liquids.—Mobility of Particles—Elasticity—Compressibility of Water—Œrsted's Experiments—Importance to the conditions of life the slight compressibility of Water—Liquid Pressure—Pressure of Liquids in every direction—Hydrostatic Paradox—Bramah's Press—Calculation of Power produced by—Application to raising Weights or to Compression—Pressure of Water at various depths—Calculation of Pressure—Important physical effects on Earth's surface dependant on Pressure—Importance of a knowledge of laws of Liquid Pressure in the construction of Walls, Embankments, &c.

Upward and Lateral Pressure.—Pressure as depth—Pressure on sides of Vessels—Examples of Pressure—Practical applications—Effects of immersion of Solids in Liquids—Loss of weight by immersion—Specific Gravity explained—Specific Gravity of Liquids and Gases—Specific Gravity of Solids ascertained by Hydrostatic Pressure—Specific Gravity of Liquids ascertained by pressure on Solid—Important applications of different Specific Gravities of solids and liquids.

Motion of Liquids.—Liquids obey laws of Inertia—Momentum of Liquids in Motion—Velocity of Efflux—Vena Contracta—Application to produce Motion in Machinery—Method of calculating Power produced by falling Water—Water Engines—Water Wheels—Reaction Wheels—Whitelaw's Mill—Turbines—Machines for raising Water—Centrifugal Pumps, different forms of—Archimedes' Screw.

PNEUMATICS.

Apparatus used in Researches on Properties of Air.—Air-pumps—Syringe—Condenser—Undulation produced in Liquids.

General Properties of Gases.—Elasticity—Density—Marriotte's Law—Weight—Atmospheric Pressure—Barometer, various forms of—Aneroid Barometer—Height of Atmosphere—Atmospheric Waves—Diurnal variation of Barometer—Method of measuring heights of Mountains by Baro-

meter—Barometer employed as indicator of Weather—Fallacy of popular ideas of its utility.

ILLUSTRATIONS OF ATMOSPHERIC PRESSURE AND ELASTICITY, AND THEIR APPLICATIONS IN THE ARTS AND TO MACHINERY.—Lift Pump—Force Pump—Fire Engine—Hero's Engine—Atmospheric Engine.—Adaptation of Pneumatic Laws to conditions of Earth's surface—Varying density of Atmosphere—Laws of Diffusion—Alterations from Heat—Bad conducting Power—Specific Heat of—Changes produced by respiration of Plants and Animals—Physical Laws adapting Atmosphere to Animal Life—Ventilation of Buildings.

ACOUSTICS.

SOUND.—Its mode of Propagation—Intensity of Sound—Velocity in Gases, Liquids, and Solids—Reflexion and Refraction of Sound—Echo and Resonnance—Interference of Sonorous Waves.

VIBRATION OF CORDS—Illustrated by Monochord—Rates of Vibration of Musical Notes—Cause of Harmony of Sounds—Harmonic Vibrations—Absolute number of Vibrations, how determined—The Sirene—Savart's Wheel—Vibrations of Air in Pipes—Of Rods and Plates—Nodal Points.

HEAT.

HEAT.—Theories of—Sources of Heat—Effects on Matter—Importance of knowledge of its effects in the Arts.

EXPANSION BY HEAT OF SOLIDS, LIQUIDS, GASES.—Coefficient of expansion—Linear and Cubical Expansion, how determined—Method of Laplace—Force of dilatation in Solids—Importance of knowledge of laws of dilatation of Solids in Arts of Construction—Relative dilatation of different classes of Solids—Application to construction of Standards of Length—Pendulums. Measures of Heat. Mechanical equivalent of Heat.

THERMOMETERS.—Principle of Thermometer—Liquids employed in its Construction—Mode of Graduation—Scale adopted in different Countries—Fahrenheit—Reaumur—Centigrade—Rules for reducing Temperature of one Scale to that of another—Sources of Error in use of Thermometers—Breguet's Thermometer—Pyrometers,—Wedgwood's—Daniel's—Exceptions to Law of Dilatation—Apparent exceptions.

Specific Heat.—Methods of determining Specific Heat—Calorimeter—Equalization of Temperature—Cooling of Bodies—Natural Phenomena dependent on different Specific Heat of Bodies.

Latent Heat.—Absorption of Heat by solution—Evolution by crystallization—Congelation—Latent Heat of Vapours—Ebullition—Elastic Force of Vapours—Application of these Laws to the principles of the Steam Engine.

Early History of Steam Engine.—First Engine devised by Hero of Alexandria—Inventions of Garay—De Caus—Branca—Marquess of Worcester—Morland—Papin—Savary—Newcomen—Watt.

Parts of Engine.—Boiler—Gauges—Feeding Apparatus—Cylinder—Piston—Crank—Valves—Spindle Valve—D Valve—Sliding Valve—Fourway Cock—Fly Wheel—Governor.

Radiation and Reflection of Heat.—Laws of Radiation—Causes modifying Radiation—Reflection of Heat from plane surfaces—Reflection from curved surfaces—Apparent reflection of Cold—Reflective power of different surfaces.

Diathermancy.—Diathermal properties of different substances—Experiments of Melloni—Theory respecting the different species of calorific rays. Actinism.

ELECTRICITY.

Electricity.—Early History of Electricity. Facts observed by Thales, Theophrastus, Pliny, &c. Sources of Electricity. Friction. Change of Form. Change of Temperature. Chemical Action. Contact or Pressure. Vital Action. Induction. Magnetic Induction. Theories of Dufay, Franklin, Eales, Cavendish, and Faraday. Different species of Electricity. Vitreous or Positive, Resinous or Negative.

Classification of Bodies with respect to their Electric Properties.—Conductors, Non-Conductors, Electrics, Non-Electrics. Defects of this Division of Bodies. Electricity of Friction produced in Idio-Electric Bodies. Classification of Bodies in reference to Conducting Power. Effects of Physical Changes in altering Electric Properties of Bodies. Insulation.

Induction.—Laws of Electrical Action on distant objects. Faraday's Theory. Electrical Attractions and Repulsions.

Apparatus employed in Electric Experiments.—Electroscopes. Condensers. Electrifying Machine. Its Action, according to Theories of Dufay and Franklin. Leyden Jar. Theory of the Leyden Jar. Unit Jar. Electrometers. Electrophorus of Volta. Distribution of Electricity in Bodies. State of Charge in Electrics. Tension, Intensity, and Quantity.

Effects of Electricity.—Mechanical Effects. Discharge through Non-Conductors and Conductors. Different Forms of Discharge. Luminous Effects. Source of Light in Discharge. Production of Ozone. Chemical Decompositions. Heat of Discharge. Magnetic Phenomena.

Atmospheric Electricity.—Thunder-storms. Lightning Conductors. Importance of knowledge of Electrical Laws in Arts of Construction. Personal Danger during Thunder-storms, how best avoided. Protection of Ships by Conductors. Comparative immunity at the present, compared with former times. Aurora Borealis. Meteors. Waterspouts.

Dynamical Electricity.—Identity of two Species of Electricity. Sources of Electricity in Motion. Discoveries of Galvani and Volta. Contact Theory of Volta. Proof by Faraday of Electromotive Force not depending on Contact. Voltaic Battery, its various Forms. Groves' Battery. Phenomena caused by. Heat and Light. Theories respecting Origin of Electromotive Force. Practical Applications. Electrolysis.

Electrotyping.—History of this Art. Application to copying Forms in different Metals. Matrices. Different kinds Electroplating. Best Methods of producing Silver Deposit. Materials employed. Electrogilding. Value and importance of this Application of Electricity in Manufactures and the Fine Arts.

Magnetism.—General Phenomena. Methods of communicating Magnetism. Magnetic Induction. Substances capable of Magnetic Induction. Effects of Heat on Magnetism. Terrestrial Magnetism. Mariner's Compass. Declination. Magnetic Meridians. Diurnal Variation. Periodical Variation. Diamagnetic Properties of Matter.

Electro-Magnetism.—Laws of Electro-Magnetic Induction. Rotation of Currents. Magnetic Electricity. Practical

Applications. Motive Power produced by Electro-Magnetism. Electricity applied to Telegraphic Purposes. Velocity of Transmission of Electric Currents.

Electric Telegraph.—Its early History. Statical Electricity first employed. Objections to its use. Submarine Telegraph. Difficulties arising from Induction. American Cable. Electro-Magnetic Force. Its Applications. Chemical Decomposition. Various Forms of Printing Telegraph. Regulation of Time by Electric Telegraph. Electric Clocks.

OPTICS.

Light.—Laws of Propagation—Velocity—Theories respecting its Cause—Refraction of Light—Snellius' Law of Sines—Lenses—Formation of Images by Lenses—Reflection of Light—Reflection from Plane Surfaces—Reflection from Curved Surfaces—Images formed by Reflection—Laws of Vision—Structure of the Eye—Optical Instruments—Reflecting and Refracting Telescopes—Microscopes—Camera.

Chromatic Phænomena.—Decomposition of Light by Prism—Recomposition of White Light—Complementary Colours—Chemical and Calorific Properties of Spectrum—Epipolic Dispersion—Diffraction of Light—Colours of Thin Plates.

Polarized Light.—Double Refraction—Undulatory Theory—Plane Polarized Light—Modes of Polarizing Light—Polariscopes—By Refraction—By Reflection—By Absorption—Colours exhibited by Polarized Light.—Application of Polarized Light in the Arts.

Text-books recommended Lardner's Handbook of Natural Philosophy; Ganot; Cours de Physique; Bird's Natural Philosophy.

CHEMISTRY.

Professor, WILLIAM K. SULLIVAN, PH.D.

GENERALITIES.

Different points of view from which bodies may be studied. Distinction between physical and chemical phenomena; characteristics of chemical phenomena; combination and decomposition. Matter is of different kinds; these different kinds are called simple bodies. All bodies are either simple or compound. Compound bodies have a constant definite composition. Two simple bodies may unite in several proportions; the numbers representing these proportions bear a very simple relation to one another.

Physical qualities which chemists employ to specify bodies: organoleptic, mechanical, thermal, optical, &c.

Divisibility of matter. Different physical states which matter can assume. Cohesion. Crystallization; isomorphism; dimorphism and polymorphism. Dissolution. Affinity. Causes which modify cohesion and affinity.

NOMENCLATURE AND CLASSIFICATION.

A nomenclature merely expresses the theoretical views of its framers; it must therefore undergo modification, or be wholly changed as the science progresses. The distinction of positively and negatively electrified bodies is, to a certain extent, the basis of the existing nomenclature. Explanation of the names of the simple bodies. Etymological principles upon which chemical names are formed. Symbolic nomenclature.

All classifications must necessarily be more or less artificial. Different ways in which we may classify the simple bodies, according to the point of view from which we may desire to study them. Division into *metalloids* and *metals.* The opinions of chemists are very unsettled as to the characteristic distinction between metals and metalloids.

METALLOIDS.

CLASSIFICATION.—The following classification will be followed in this Course:—*Amphigens*—Oxygen, Sulphur, Selenium, Tellurium; *Halogens*—Fluorine, Chlorine, Bromine, Iodine; *Phosphoroids*—Nitrogen, Phosphorus, Arsenic, Antimony; *Carboids*—Carbon, Boron, Silicon; *Unclassed*

—Hydrogen. *Simple Bodies which may, perhaps, be classed as Metalloids*—Zirconium, Osmium,

DESCRIPTION.—Comparative physical and chemical properties of the bodies of each group. Condition in which they occur in nature. Uses in their uncombined state.

COMBINATIONS.—I. *Compounds formed by the Amphigens with*—1 *Hydrogen*. Examples: Water, deutoxide of hydrogen, protosulphide and deutosulphide of hydrogen.

Water.—Different circumstances under which oxygen and hydrogen gases combine. Physical properties of water in different states. Spheroidal condition of water. Chemical functions of water. Natural waters; their purification. Analytic methods employed to establish the composition of water. Synthesis of water; eudiometers. Preparation and properties of deutoxide of hydrogen or oxygenated water, and of the protosulphide and bisulphide of hydrogen.

2. With the *Halogens*.—Special examples:—hypochlorous, chloric, and perchloric acids; bromic and iodic acids; chlorides of sulphur. Preparation, physical and chemical properties of those bodies. Uses in the arts.

3. With the *Phosphoroids*.—Special examples:—Protoxide and deutoxide of nitrogen, nitrous acid, peroxide of nitrogen, nitric acid; hypophosphorous, phosphorous, and phosphoric acids; arsenious and arsenic acids, sulphides of arsenic,—orpiment, and realgar; oxides and sulphides of antimony. Preparation, physical and chemical properties of those bodies. Uses in the arts.

Atmospheric Air.—Qualitative analysis of air. Experiment of Lavoisier. Processes employed for the analysis of air. Composition of the atmosphere. Proofs that air is a mixture and not a compound. Physical properties of atmospheric air. Functions of the atmosphere.

4. With the *Carboids*.—Special examples: Protoxide of carbon, carbonic acid, sulphides of carbon; boracic and silicic acids. Their preparation, physical and chemical properties. Uses in the arts.

5. With *one another*.—Special examples: sulphurous, sulphuric, and the other oxygen acids of sulphur. Their preparation, physical and chemical properties. Uses in the arts.

II.—*Compounds formed by the Halogens with*—1. *Hydrogen*.—Special examples: Hydrofluoric, hydrochloric, hydrobromic, and hydriodic acids. Preparation, physical and chemical properties of those bodies. Remarkable example of analogy of composition which they offer. Uses in the arts.

2. With the *Phosphoroids*.—Special examples: chlorides of nitrogen, phosphorous, arsenic, and antimony. Preparation,

physical and chemical properties of those bodies. Uses in the arts.

3. With the *Carboids*.

III. *Compounds formed by the Phosphoroids with*—1. *Hydrogen*. Examples: Amines, amides and ammoniums —amine or common ammonia, ammonium; phosphine, arsine, stibine. Preparation, physical and chemical properties of those bodies. Phosphine, arsine, and stibine may be regarded as ammonia, in which the nitrogen is replaced by phosphorus, arsenic, and antimony, respectively. The hydrogen may also be considered capable of a similar replacement; a large class of bodies, the amines and amides, are considered to be formed in this way. Ammonium a type of the metallic compound radicals. Uses of this series of compounds in the arts.

2. With the *Carboids*.—Example: Cyanogen. Preparation, physical and chemical properties of that body. Importance of cyanogen as a type of the metalloid compound radicals. Combinations of cyanogen with the metalloids: hydrocyanic acid, cyanic and cyanuric acids, chlorides of cyanogen. Radicals derived from cyanogen, or, which contain carbon and nitrogen: radicals formed by metallic cyanides,—platino-, palladio-, ferro-, iridio-, Ferrid-, cobalto-, chromo-, mangano-cyanogens: sulpho-cyanogen, mellone, &c.

IV. *Compounds formed by the Carboids with Hydrogen.*—Examples: Carbides of hydrogen. General properties of those compounds. Many of them contain the same proportion of carbon and hydrogen, although they differ in properties; use of the term isomeric to distinguish such bodies. Homologous and isologous series.

Stoicheiometry.—Summary of the laws which govern the combinations of bodies by weight and volume. Proportional weights and volumes of bodies. Equivalent weights and volumes. Atomic theory. Establishment of formulæ; physical and chemical formulæ; chemical formulæ are of different values; importance of these distinctions.

Comparative view of the composition by weight and volume of the compounds of the metalloids with one another; and of the analogies in composition and properties that the corresponding compounds, which the same body forms with each member of a group of metalloids, offers.

METALS.

Classification.—Different ways in which metals may be classified. Classification adopted in this course:—

I. Class.—Potassium, Sodium, Lithium, Barium, Strontium, Calcium.

II. Class.—Magnesium, Aluminium, Manganese; and probably Glucinium, Zirconium (if not placed among the metalloids), Yttrium, Thorium, Cerium, Lanthanium, Didimium, Erbium, Terbium.

III. Class.—Iron, Nickel, Cobalt, Chromium, Vanadium, Zinc, Cadmium, Uranium.

IV. Class.—Tungsten, Molybdenum, Osmium (if not classed with the metalloids), Tantalum, Titanium, Tin, Antimony (if classed with the metals); and perhaps Niobium.

V. Class.—Copper, Lead, Bismuth.

VI. *a.* Rhodium, Mercury.

b. Silver, Iridium, Palladium, Platinum, Ruthenium, Gold.

Physical Properties.—Comparative physical properties of each group of metals (density, malleability, tenacity, ductility, colour, &c.).

Chemical Properties.—I. *Action of Amphigens upon Metals.*

1. *Oxygen.*—Action of moist and dry oxygen on the metals of each class. Methods of preparing oxides. Classification of oxides according to their chemical and physical properties. Action of heat, light, and electricity upon metallic oxides; action of the other amphigens, of the halogens, phosphoroids, and carboids, and of hydrogen upon metallic oxides. Action of metals upon metallic oxides.

2. *Sulphur.*—Action of sulphur upon metals. Methods of preparing metallic sulphides. Classification of metallic sulphides. Action of oxygen, the halogens, phosphoroids, carboids, hydrogen, and the metals upon metallic sulphides. Action of heat, light, and electricity.

II. *Action of the Halogens upon Metals.* 1. *Chlorine.*—Action of chlorine upon metals. Methods of preparing metallic chlorides. Classification of metallic chlorides. Action of heat, light, electricity, the amphigens, phosphoroids, carboids, hydrogen, and the metals upon metallic chlorides.

2. Action of *Fluorine*, *Bromine*, and *Iodine* upon metals, and general characters of the resulting compounds.

III. *Action of the Phosphoroids and Carboids upon Metals.*

IV. Compounds of the metals with one another.—Alloys.

Summary.—General comparative physical and chemical properties of the oxides, sulphides, fluorides, chlorides, bromides, and iodides of each class of metals.

INDUSTRIAL APPLICATIONS.—General notions on metallurgy. Oxides, sulphides, fluorides, chlorides, bromides, and iodides used in the arts.

SALTS.

GENERALITIES.—Action of acids upon bases; different ways in which the phenomena may be explained. Dualistic or acid and base theory; definition of a salt upon this hypothesis; according to this view the simple chlorides, bromides, &c., or halogenical salts, do not belong, properly speaking, to the category of salts at all; different kinds of salts according to this hypothesis. Oxy-, sulpho-, chloro-, &c., salts. Distinction between basic, acid, and neutral salts.

The salt radical theory is founded upon the hypothesis of compound radicals. Theory of types. Doctrine of substitution. Hypothesis that all chemical changes are the results of double decomposition. Types from which we may suppose bodies to be derived by double decomposition:

I. *Water*, $\left.\begin{matrix}H\\H\end{matrix}\right\}O_2$ from which are derived the compounds of the amphigens: oxides, sulphides, selenides, tellurides.

II. *Hydrochloric Acid*, HCl. from which are derived compounds of the halogens: chlorides, bromides, iodides, fluorides, and cyanides

III. *Ammonia*, $N\left\{\begin{matrix}H\\H\\H\end{matrix}\right\}$ from which are derived the compounds of the phosphoroids: nitrides, phosphides, arsenides, stibides.

IV. *Hydrogen* HH, the type of elementary bodies, hydrides of metals, and compound radicals.

Constitution of hydrated acids and bases, anhydrous acids and bases, and of salts, upon this theory. Nature of polyatomic acids. Theory of ammonium salts; bases formed by the action of ammonia upon salts of mercury, platinum, &c.

RELATIONS OF WATER TO SALTS.—Functions of water in salts; hydrated water; water of crystallization; the whole of the crystalline water not always held with equal force,—constitutional water. Phenomena of solution.

DESCRIPTION.—Physical and chemical properties of the following families of salts,—sulphates, chlorates, nitrates, phosphates, arseniates, carbonates, borates, silicates, &c.

CHEMICAL ACTION OF SALTS ON EACH OTHER.—Laws of Berthollet. Malaguti's coefficient of decomposition. Experiments of Bunsen and others on the influence of mass on chemical decomposition.

ANALYSIS OF SALTS.—Elementary principles of chemical analysis.

ORGANIC CHEMISTRY.

Generalities.—Definition of an organic body. Distinction made by chemists between organized and organic substances. Elementary composition of organic bodies. Proximate analysis of plants and animals. Ultimate analysis of organic substances. Establishment of formulæ.

Proximate Principles of Plants and Animals.—The proximate principles of plants and animals the foundation of organic chemistry.

Cellulose.—Properties of cellulose. Proximate principles of wood—paracelulose, or the matter of the cellular or utricular tissue; fibrose, or the matter of the fibrous tissue; and vasculose, or the matter of the vessels proper.

Starch.—Different kinds of starch; inuline, lichen starch, &c. Action of heat in the presence of water upon starch. Dextrine—different kinds of dextrine.

Gums.—Gummic and metagummic acids; nature of arabine and cerasine; bassorine. Pectose, and the gelatinous principles of fruits derived from it.

Saccharine Bodies.—These substances may be classified into four groups—1, glucoses, of which there are probably many isomeric varieties, some deviating the plane of polarization to the right (grape sugar, starch sugar, diabetic sugar, maltose, &c.,) and others to the left (left-handed fruit sugar, the left-handed glucose derivable from cane sugar by the action of acids, &c.); 2, saccharine bodies having the same proportions of carbon, hydrogen, and oxygen, as glucose, but not fermentescible (sorbine, eucalyne, inosite, &c.); 3, compound sugars yielding one or more glucoses, and, therefore, properly belonging to the class of glucosides (cane sugar, melitose, mycose, trehalose, &c.); 4, saccharine bodies which do not ferment, and which contain proportionably less oxygen than the groups 1, 2, and 3 (mannite, dulcite, phycite, quercite, pinite, &c.)

Glucosides.—Nature of glucosides; importance of this class of bodies; different classes of glucosides—1, glucosides which yield glucose and neutral bodies free from nitrogen, (salicine, arbutine, phlorizine, cane sugar, &c.); 2, glucosides which yield glucose and acids (tannins, &c.); 3, glucosides which yield glucose and contain nitrogen (amygdaline myronic acid, and perhaps gelatine, and many other animal substances); 4, glucosides which appear to contain some substance belonging to the starch series, or some kind of saccharine substance not belonging to the glucose group, and some of which contain nitrogen, sulphur, and phosphorus (cork,

cutine, white chyle, globules from which hæmatine, and the colouring matter of the bile, are apparently derived; and, lastly, the bodies from which chlorophyl and many other colouring matters, both vegetable and animal, are derived.)

Fruit acids, vegetable alkaloids, essential oils, &c.

Albuminoid bodies: fibrine, albumen, vitelline, caseine, gluten, legumine, amandine, &c.

Gelatinous tissues: chondrine, gelatine.

Proximate principles of the bile: taurocholic, cholic and hyocholic acids and their derivatives. Cholestearin.

Proximate principles of flesh: creatine and creatinine, inosic acid, &c.

Hippuric and uric acids and their derivatives, &c.

Fermentation.—Nature of fermentation; hypothesis proposed to explain the phenomena; different kinds of fermentation—alcoholic, lactic, butyric, &c. Products of alcoholic fermentation—alcohol; action of acids upon alcohol—sulphovinic acid; ether; theory of the production of ether. Simple ethers formed with the amphigens; simple ethers formed with the halogens. Compound ethers.

Alcoholides.—Common alcohol the type of a numerous class of bodies. General characteristics of this class of compounds.

Monatomic Alcohols: 1. Alcohols homologous with vinic or common alcohol; methylic, propylic, amylic, and other alcohols, represented by the general formula $C_{2m}H_{2m+2}O_2$, in which the homologous radicals $C_{2m}H_{2m+1}$ are assumed; and their simple and compound ethers. 2. Alcohols of the formula $C_{2m}H_{2m}O_2$, in which the radicals $C_{2m}H_{2m-1}$, are assumed, or the allylic series; and their derivatives. 3. Alcohols of the formula $C_{2m}H_{2m-2}O_2$. Alcohols of the formula $C_{2m}H_{2m-6}O_2$, in which the radicals $C_{2m}H_{2m-7}$ are assumed, or the benzoic series, and the isomeric series, represented by phenylic alcohol and its homologues; and their more important derivatives.

Biatomic alcohols or Glycols: 1. Glycols homologous with common glycol, and represented by the general formula $C_{2m}H_{2m+2}O_4$. 2. Glycols represented by the formula $C_{2m}H_{2m-6}O_4$, and related to the benzoic monatomic alcohol series.

Triatomic alcohols. Glycerine. Compound ethers of glycerine—glycerides or fats. Summary of the more important glycerides forming animal and vegetable fats: acetines, butyrines, valerines, laurostearines, myristines, palmitines, margarines, oleines, &c.

Mixed or conjugate ethers.

Aldehydes and Acetones.—Nature of aldehydes; relation between them and alcohols and acids.

The series of Aldehydes known at present: 1. Aldehydes of the formula $C_{2m}H_{2m}O_2$, derivable from the vinic alcohol series; 2. Aldehydes of the formula $C_{2m}H_{2m-2}O_2$, derivable from the allylic alcohol series; 3. Aldehydes of the formula $C_{2m}H_{2m-8}O_2$, derivable from the benzoic alcohol series. Nature of acetones; relation between them and aldehydes.

Monatomic Acids derivable by Oxidation from Monatomic Alcohols.—1. Acids of the formula $C_{2m}H_{2m}O_4$, derivable from vinic alcohol and its homologues—formic, acetic, propylic, butyric, &c., acids. 2. Acids of the formula $C_{2m}H_{2m-2}O_4$, derivable from the alcohols $C_{2m}H_{2m}O_2$,—acrylic, angelic, oleic, &c., acids. 3. Acids of the formula $C_{2m}H_{2m-4}O_4$, corresponding to the alcohol series $C_{2m}H_{2m-2}O_2$, sorbic and parasorbic acids. 4. Acids of the formula $C_{2m}H_{2m-8}O_4$, derivable from the benzoic alcohol series $C_{2m}H_{2m-6}O_2$, the aromatic acids—benzoic, toluylic, &c., acids and their homologues.

Acids related to Glycols or Biatomic Alcohols.

Monatomic: 1. Acids of the formula $C_{2m}H_{2m}O_6$ related to the glycols $C_{2m}H_{2m+2}O_4$, lactic acid, &c. 2. Acids of the formula $C_{2m}H_{2m-8}O_6$ related to the glycols $C_{2m}H_{2m-6}O_4$, salicylic, phloretic, &c., acids.

Biatomic: 1. Acids of the formula $C_{2m}H_{2m-2}O_8$ related to the glycols $C_{2m}H_{2m+2}O_4$, oxalic, succinic, adipic, suberic, &c., acids. 2. Acids of the formula $C_{2m}H_{2m-10}O_8$ related to the glycols $C_{2m}H_{2m-6}O_4$, phtalic acid and its homologues.

Non-Volatile Acids which yield Pyrogenic Acids.—Malic acids and its derivatives—malic acid and paramalic or fumaric acid. Tartaric acid; its different forms; action of heat upon tartaric acid—pyrotartaric and pyruvic acids. Citric acid and its derivatives—aconitic, itaconic, citraconic, and mesaconic acids. Mucic acid; action of heat upon it—pyromucic acid. Meconic acid and its derivatives—comenic and pyromeconic acids. Kinic acid and its derivatives—kinone and hydrokinone. Gallic acid; action of heat upon it—pyrogallic acid.

Carbides of Hydrogen.—Generalities on compound radicals. Relation of compound radicals to the carbides of hydrogen; hydurets; mixed or conjugate carbides. Classification of the carbides of hydrogen into homologous series: 1, homologues of marsh gas $C_{2m}H_{2m+2}$; 2, homologues of ethylene $C_{2m}H_{2m}$; 3, homologues of acetylene $C_{2m}H_{2m-2}$; 4, oil of turpentine group, and its isomeres $C_{2m}H_{2m-4}$; 5, Benzene

series $C_{2m}H_{2m-6}$; 6, cinnamene and its homologues $C_{2m}H_{2m-8}$; 7, naphtalene and its homologues $C_{2m}H_{2m-12}$; 8, stilbene series $C_{2m}H_{2m-16}$.

Compounds of carbides of hydrogen with the simple metals: Zincomethyle and zincethyle; natri- and kali-ethyle; compounds of ethyle and methyle with magnesium and aluminium; stannethyles and stannomethyles; plumbomethyles and plumbethyles; mercurosi- and mercuri-methyle, mercurosethyle and mercurethyle; arsenmonomethyle, arsendimethyle (kakodyle), arsentrimethyle, arsentetramethyle, corresponding compounds of arsenic with ethyle; stibmethyle and stibethyle, stibmethylium and stibethylium; bismuthethyle and bismuthtriethyle, and the corresponding compounds with methyle. These bodies show that in all the combinations of the simple bodies, the conditions of stable equilibrium are best fulfilled by certain molecular groups. Influence which the study of these bodies is likely to exert on our notions regarding simple and compound radicals.

Amines and Amides and Natural Organic Bases.—Action of heat upon neutral ammoniacal salts, and nature of the products,—oxamide, acetamide, &c. Action of heat upon salts of bibasic acids containing an equivalent of basic water—oxamic, and succinamic acids. Action of heat and of dehydrating substances on the amides of monobasic acids—*Nitryles.* Action of the simple ethers formed by the halogens upon ammonia at a high temperature—ex. bromides of methyle, and of ethyl; character of the resulting compounds. Derivatives of ammonia may therefore be either acid, basic, or neutral. The basic ones are distinguished as *amines*, and may be considered to be ammonia, in which the whole or part of the hydrogen has been replaced by compound or simple metallic or positive radicals. The neutral and acid derivatives are termed *amides*, and may be considered as ammonia, in which the hydrogen is replaced by negative compound or simple radicals. Amines and amides are either monatomic or polyatomic according as they may be considered derivable from one, two, or more equivalents of ammonia,—monamines and monamides, diamines and diamides, &c. Each of these is again subdivided into primary, secondary, and tertiary amines and amides, according as one, two, or three equivalents, or one, two, or three pairs of equivalents of hydrogen are replaced. Amines and amides may form bodies of the ammonium type. Corresponding compounds may also be obtained with phosphorus, arsenic, and antimony.

History of the more important artificial bases of each class; primary or *amide* bases, secondary or *imide* bases and tertiary or *nitryle* bases, formed by the substitution of carbo-hydrogen radicals; oxygenated bases formed by the substitution of NO_4, &c.; *ureas,*—generalities on ureas, normal urea, compound ureas, ureas formed by the substitution of acid radicals; ureas derived from phosphamine

Natural alkaloids or vegetable bases, and their most important derivatives. Family of the *Caesalpineae*—surinamine, jamaicine; *Papilionaceae*—sparteine; *Rutaceae*—harmaline; *Diosmeae*—cusparine; *Euphorbiaceae*—crotonine, buxine; *Meliaceae*—azadarine, carapine; *Büttneriaceae*—theobromine; *Papaveraceae*—opium bases, (morphine, codeine, thebaine, papaverine, narcotine, narceine), bases of the Eschscholtzia, bases of the Chelidonium majus—(chelodonine, chelerythrine), bases of glaucium luteum—(glaucine, glaucopicrine); *Fumariaceae*—corydaline; *Ranunculaceae*—aconitine, delphine, staphisine; *Menispermeae*—menispermine, pelosine; *Berberideae*—oxycanthine; *Umbelleferae*—coniine cynapine; *Rubiaceae*—cinchona bases, (quinine, quinidine, quinicine, cinchonine, cinchonidine, cinchonicine, aricine), emetine, cafeine (found also in the families *Camelliaceae*, *Sapindaceae*, &c.); *Loganieae*—strychnine, brucine, curarine; *Solenaceae*—nicotine solanine, atropine, hyoscyamine, daturine stramonine, capsicine; *Thymelaeae*—daphnine; *Laurineae*—bebeerine; *Piperaceae*—piperine; *Palmae*—apyrine; *Colchicaceae*—colchicine, veratrine, sabadiline, jervine, &c.

Summary of the classes of ammonia derivatives according chiefly to Hofmann:—

I. Ammonia Type.

Positive Series produced by the substitution of basic radicals.

A. Organo-Amines.

a. Monamines.

α. Primary monamines.

Ex. $\left.\begin{matrix} C_2H_3 \\ H \\ H \end{matrix}\right\} N.$ $\quad$ $\left.\begin{matrix} C_nH_{n+1} \\ H \\ H \end{matrix}\right\} N.$

β. Secondary monamines.

Ex. $\left.\begin{matrix} C_2H_3 \\ C_2H_3 \\ H \end{matrix}\right\} N.$ $\quad$ $\left.\begin{matrix} C_4\,H_5 \\ C_{12}H_5 \\ H \end{matrix}\right\} N.$

γ. Tertiary monamines.

Ex. $\left.\begin{matrix} C_2H_3 \\ C_2H_3 \\ C_2H_3 \end{matrix}\right\} N.$ $\quad$ $\left.\begin{matrix} C_2\,H_3 \\ C_4\,H_5 \\ C_{12}H_5 \end{matrix}\right\} N.$

b. Diamines.

Type. Ammonia.

$\left.\begin{matrix} H \\ H \\ H \end{matrix}\right\} N.$

$\left.\begin{matrix} A \\ H \\ H \end{matrix}\right\} N.$

$\left.\begin{matrix} A \\ B \\ H \end{matrix}\right\} N.$

$\left.\begin{matrix} A \\ B \\ C \end{matrix}\right\} N.$

Type. Diammonia.

$\left.\begin{matrix} H_2 \\ H_2 \\ H_2 \end{matrix}\right\} N_2.$

Negative Series produced by the substitution of acid radicals.

A. Organo-Amides.

a. Monamides.

α. Primary Monamides.

Ex. $\left.\begin{matrix} C_4\,H_3\,O_2 \\ H \\ H \end{matrix}\right\} N.$ $\quad$ $\left.\begin{matrix} C_4\,Cl_3\,O_2 \\ H \\ H \end{matrix}\right\} N.$

β. Secondary Monamides.

Ex. $\left.\begin{matrix} C_4\,H_3\,O_2 \\ C_4\,H_3\,O_2 \\ H \end{matrix}\right\} N.$ $\quad$ $\left.\begin{matrix} (C_2\,O_2)'' \\ H \end{matrix}\right\} N.$

γ. Tertiary Monamides.

Ex. $\left.\begin{matrix} C_{12}\,H_5\,O_4\,S_2 \\ C_{14}\,H_5\,O_2 \\ C_{20}\,H_{11}\,O_2 \end{matrix}\right\} N.$

b. Diamides.

	Type.	
a. **Primary diamines.** *Ex.* $\left.\begin{matrix}(C_2O_2)'' \\ H_2 \\ H_2\end{matrix}\right\} N_2.$ $\left.\begin{matrix}(C_{12}H_4)'' \\ H_2 \\ H_2\end{matrix}\right\} N_2.$	$\left.\begin{matrix}A_2 \\ H_2 \\ H_2\end{matrix}\right\} N_2.$	*a.* Primary Diamides. *Ex.* $\left.\begin{matrix}(C_4\,O_4)'' \\ H_2 \\ H_2\end{matrix}\right\} N_2$ $\left.\begin{matrix}(C_8\,H_4\,O_4)'' \\ H_2 \\ H_2\end{matrix}\right\} N_2$
β. Secondary diamines. *Ex.* $\left.\begin{matrix}(C_2O_2)'' \\ (C_4H_5)^2 \\ H_2\end{matrix}\right\} N_2.$ $\left.\begin{matrix}(C_2S_2)'' \\ C_4H_5, C_6H_5 \\ H_2\end{matrix}\right\} N_2.$	$\left.\begin{matrix}A_2 \\ B_2 \\ H_2\end{matrix}\right\} N_2.$	*β.* Secondary Diamides. *Ex.* $\left.\begin{matrix}(C_2\,O_2)'' \\ (C_{12}\,H_5)^2 \\ H_2\end{matrix}\right\} N_2$ $\left.\begin{matrix}(C_2O_2)'' \\ C_{14}H_5O_2, H \\ H_2\end{matrix}\right\} N_2$
γ. Tertiary diamines. *Ex.* $\left.\begin{matrix}(C_2\,O_2)'' \\ C_4\,H_5, H \\ (C_{10}H_{11})''\end{matrix}\right\} N_2.$	$\left.\begin{matrix}A_2 \\ B_2 \\ C_2\end{matrix}\right\} N_2.$	*γ.* Tertiary Diamides. *Ex.* $\left.\begin{matrix}(C_8\,H_4\,O_4)'' \\ (C_8\,H_4\,O_4)'' \\ (C_8\,H_4\,O_4)''\end{matrix}\right\} N_2$
c. *Triamines* (not yet well known).	Triammonia. $\left.\begin{matrix}H_3 \\ H_3 \\ H_3\end{matrix}\right\} N_3.$	*c.* *Triamides.*
	$\left.\begin{matrix}A_3 \\ H_3 \\ H_3\end{matrix}\right\} N_3.$	*a.* Primary Triamides. *Ex.* $\left.\begin{matrix}(C_{12}\,H_5\,O_8)''' \\ H_3 \\ H_3\end{matrix}\right\} N_3$
	$\left.\begin{matrix}A_3 \\ B_3 \\ H_3\end{matrix}\right\} N_3.$	*β.* Secondary Triamides. *Ex.* $\left.\begin{matrix}(PO_2)''' \\ (C_{12}\,H_5)^3 \\ H_3\end{matrix}\right\} N_3$
	$\left.\begin{matrix}A_3 \\ B_3 \\ C_3\end{matrix}\right\} N_3.$	*γ.* Tertiary Triamides. *Ex.* $\left.\begin{matrix}(C_2\,O_2)''_3 \\ (C_4\,H_5)^3\end{matrix}\right\} N_3.$

I. *Ammonia Type*—continued.

Positive Series.	*Type.* Tetrammonia.	*Negative Series.*
A. ORGANO-AMINES—*continued.*		A. ORGANO-AMIDES—*continued.*
d. Tetramines, &c.	$\left.\begin{matrix}H_4\\H_4\\H_4\end{matrix}\right\}N_4.$	*d. Tetramides, &c.*
B. ORGANO-PHOSPHINES.	$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}P.$	B. ORGANO-PHOSPHIDES.
a. Monophosphines.		*a. Monophosphides.*
	$\left.\begin{matrix}A\\H\\H\end{matrix}\right\}P.$	α. Primary Monophosphides. *Ex.* $\left.\begin{matrix}C_4Cl_3O_2\\H\\H\end{matrix}\right\}P.$
γ. Tertiary Monophosphines. *Ex.* $\left.\begin{matrix}C_2H_3\\C_2H_3\\C_2H_3\end{matrix}\right\}P.$	$\left.\begin{matrix}A\\B\\C\end{matrix}\right\}P.$	γ. Tertiary Monophosphides. *Ex.* $\left.\begin{matrix}C_{14}H_5O_2\\C_{14}H_5O_2\\C_{14}H_5O_2\end{matrix}\right\}P.$
C. ORGANO-ARSINES.	$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}As.$	
a. Monarsines.		
γ. Tertiary Monarsines. *Ex.* $\left.\begin{matrix}C_4H_5\\C_4H_5\\C_4H_5\end{matrix}\right\}As.$	$\left.\begin{matrix}A\\B\\C\end{matrix}\right\}As.$	

D. ORGANO-STIBINES.

Type.

a. Monostibines. $\left.\begin{matrix} H \\ H \\ H \end{matrix}\right\} Sb.$

γ. Tertiary Monostibines. $\left.\begin{matrix} A \\ B \\ C \end{matrix}\right\} Sb.$

Ex. $\left.\begin{matrix} C_4H_5 \\ C_4H_5 \\ C_4H_5 \end{matrix}\right\} Sb.$

E. METALAMIDES, METALPHOSPHIDES, METALARSIDES, METALSTIBIDES.

Examples, $\left\{ \left.\begin{matrix} K \\ H \\ H \end{matrix}\right\} N. \quad \left.\begin{matrix} Zn \\ H \\ H \end{matrix}\right\} N. \quad \left.\begin{matrix} K \\ K \\ K \end{matrix}\right\} N. \quad \left.\begin{matrix} Hg \\ Hg \\ Hg \end{matrix}\right\} N. \quad \left.\begin{matrix} Co \\ Co \\ Co \end{matrix}\right\} P. \quad \left.\begin{matrix} Cu \\ Cu \\ Cu \end{matrix}\right\} As. \quad \left.\begin{matrix} Ag \\ Ag \\ Ag \end{matrix}\right\} Sb. \right.$

MIXED DERIVATIVES; that is, bodies derived from ammonia by the substitution of both basic and acid radicals.

a. α. Secondary monamides, containing one monatomic acid radical and one monatomic alcohol radical. *Ex.* $\left.\begin{matrix} C_2H_3 \\ C_4H_3O_2 \\ H \end{matrix}\right\} N.$

β. Tertiary monamides, containing two acid monatomic radicals, or one diatomic, and one alcohol radical. *Ex.* $\left.\begin{matrix} C_4H_5 \\ C_4H_3O_2 \\ C_4H_3O_2 \end{matrix}\right\} N.$

b. α. Secondary diamides, containing one diatomic acid radical, and two monatomic alcohol radicals. *Ex.* $\left.\begin{matrix} (C_4O_4)'' \\ (C_4H_5)^2 \\ H_2 \end{matrix}\right\} N_2.$

β. Tertiary diamides, containing two diatomic acid radicals, and two monatomic alcohol radicals. *Ex.* $\left.\begin{matrix} (C_2O_2)'' \\ (C_4O_4)'' \\ (C_{12}H_5)^2 \end{matrix}\right\} N_2.$

c 2

I. *Ammonia Type*—continued.

Positive Series.		*Negative Series.*

G. Organo-Metalamides, or mixed derivatives, in which the positive radical is a simple metal.

a. Monamides.

α. Secondary. *Ex.* $\left.\begin{matrix} C_{14}H_5O_2 \\ Hg \\ H \end{matrix}\right\} N.$ $\left.\begin{matrix} C_4H_3O_2 \\ Zn \\ H \end{matrix}\right\} N.$

β. Tertiary. *Ex.* $\left.\begin{matrix} C_4H_5 \\ C_4H_5 \\ Zn \end{matrix}\right\} N.$ $\left.\begin{matrix} (C_2O_2)'' \\ K \end{matrix}\right\} N.$

b. Diamides.

α. Secondary. *Ex.* $\left.\begin{matrix} (C_4O_4)'' \\ Zn_2 \\ H_2 \end{matrix}\right\} N_2.$

II. *Water Type.*

Positive Series	Type	Negative Series
A. Organo-Ammoniums.		A. Organo-Amidic Acids.
a. Monammoniums.	$\left.\begin{matrix} [H_4N] \\ H \end{matrix}\right\} O_2.$	*a. Monamidic acids.*
	$\left.\begin{matrix} [ABH_2N] \\ H \end{matrix}\right\} O_2.$	β. Secondary monamidic acids. *Ex.* $\left.\begin{matrix} [(C_4O_4)''H_2N] \\ H \end{matrix}\right\} O_2.$
	$\left.\begin{matrix} [ABCHN] \\ H \end{matrix}\right\} O_2.$	γ. Tertiary monamidic acids. *Ex.* $\left.\begin{matrix} [(C_4O_4)''(C_4H_5)HN] \\ H \end{matrix}\right\} O_2.$

δ. Quartary Monammonium bases. *Ex.* $\left.\begin{matrix}[(C_2H_3)^4N] \\ H\end{matrix}\right\}O_2.$ $\left.\begin{matrix}\begin{bmatrix}(C_2H_3)\ (C_4H_5)N \\ (C_{10}H_{11})\ (C_{12}H_5\end{bmatrix} \\ H\end{matrix}\right\}O_2.$	$\left.\begin{matrix}[ABCDN] \\ H\end{matrix}\right\}O_2.$	δ. Quartary monamidic acids. *Ex.* $\left.\begin{matrix}[(C_{12}H_5O_2)'''(C_{12}H_5)N] \\ H\end{matrix}\right\}O_2.$
b. Diammoniums.	*Type.* $\left.\begin{matrix}[H_8N_2]'' \\ H^2\end{matrix}\right\}O_2.$	*b. Diamidic acids.*
δ. Quartary Diammoniums. *Ex.* $\left.\begin{matrix}[(C_4H_5)^2(C_{10}H_7)_2'''\}N_2]'' \\ H_2\end{matrix}\right\}O_4.$	$\left.\begin{matrix}[A_2B_2C_2D_2N]'' \\ H_2\end{matrix}\right\}O_2.$	δ. Quartary diamidic acids.
B. METALAMMONIUMS.		B. METALAMIDIC ACIDS.
a. Ammoniums, in which simple metals replace hydrogen.	*Type.* $\left.\begin{matrix}[M(H_3N) \\ H\end{matrix}\right\}O_2.$	
b. Ammoniums, in which ammonium itself, or its derivatives, may be considered the replacing metal; or the *amine-ammoniums.* *Ex.* $\left.\begin{matrix}\left[(C_2H_3)\left((C_4H_4)_2''(C_{12}H_5)^2\}N_2\right)\right] \\ H\end{matrix}\right\}O_2.$	$\left.\begin{matrix}[H(H_3N)_2 \\ H\end{matrix}\right\}O.$ or $\left.\begin{matrix}\left[\left.\begin{matrix}H \\ H \\ H \\ (H_4N)\end{matrix}\right\}N\right] \\ H\end{matrix}\right\}O_2.$	*b. Diamine amidic acids.* *Ex.* $\left.\begin{matrix}\left[H\left((C_4O_4)''(C_{12}[H_8,NO_4])''H_2N_2\right)\right] \\ H\end{matrix}\right\}O_2.$

II. *Water Type*—continued.

Positive Series.

B. METALAMMONIUMS—*continued.*

c. *Organo-metalammoniums,* in which simple metals and organic metals are both substituting the hydrogen.

Ex. The hydrated oxide corresponding to the chloride—

$[Pd.(C_4H_5)H_4N]Cl$, that is—

$$\left.\begin{matrix}[Pd.(C_4H_5)H_2N] \\ H\end{matrix}\right\} O_2.$$

Under this category may also be placed the *organo-metalamine ammoniums,* or those in which the hydrogen may be considered to be simultaneously substituted by a simple metal, an organic metal, and ammonium or its derivatives.

C. PHOSPHONIUMS.

a. *Monophosphoniums.*

Ex. $\left.\begin{matrix}[(C_2H_3)^4P] \\ H\end{matrix}\right\} O_2.$

b. *Diphosphoniums.*

Ex. $\left.\begin{matrix}[(C_4H_5)^6(C_4H_4)''P_2]'' \\ H_2\end{matrix}\right\} O_4.$

c. *Phosphammoniums,* or compounds containing ammonium and phosphonium.

Ex. $\left.\begin{matrix}[(C_4H_5)^3(C_4H_4)''H_3PN]'' \\ H_2\end{matrix}\right\} O_4.$

Negative Series.

D. Arsoniums.

a. Monarsoniums.

Ex. $\left.\begin{matrix}[(C_4H_5)^4As]\\ H\end{matrix}\right\}O_2.$

b. Diarsoniums.

Ex. $\left.\begin{matrix}[(C_4H_4)''(C_4H_5)_6As_2]''\\ H_2\end{matrix}\right\}O_4.$

c. Arsamoniums, or compounds containing ammonium and phosphonium.

Ex. $\left.\begin{matrix}[(C_4H_4)''(C_4H_5)_3H_3AsN]''\\ H_2\end{matrix}\right\}O_4.$

d. Phospharsoniums, or compounds containing phosphonium and arsonium.

Ex. $\left.\begin{matrix}[(C_4H_4)''(C_4H_5)_6PAs]''\\ H_2\end{matrix}\right\}$

E. Stiboniums. *Ex.* $\left.\begin{matrix}[(C_2H_3)^4Sb]\\ H\end{matrix}\right\}O_2.$

Formation of ammonia derivatives. Natural organic bases; their relations to the amines and ammoniums. Summary of the chief organic bases.

Metamorphosis of Organic Compounds.—The transformations of organic bodies are generally either heterologous, homologous, or isologous. The agents employed to effect these transformations are either agents of substitution or double decomposition; agents of combustion or oxidation; agents of deoxidation or reduction. Examples of the mode of action of the more important agents of each of these classes.

Classification of Chemical Substances according to the Theory of Types. This classification abolishes the artificial distinction between organic and inorganic bodies. Other advantages which it possesses. Synoptic view of this classification according to Gerhardt.

I. *Type, Water,* $n\left.\begin{matrix}H\\H\end{matrix}\right\}O_2$.

OXIDES.

Positive Series.

A. Bases, properly so called.

a. Primary bases, or *hydrated oxides.*

Monatomic.

Ex.

$\left.\begin{matrix}K\\H\end{matrix}\right\}O_2$ Hydrate of potash.

$\left.\begin{matrix}HO_2\\H\end{matrix}\right\}O_2$ Peroxide of hydrogen.

$\left.\begin{matrix}NHg_4\\H\end{matrix}\right\}O_2$ Hydrate of tetramercurammonium.

$\left.\begin{matrix}N(C_4H_5)^4\\H\end{matrix}\right\}O_2$ Hydrate of tetrethylium.

$\left.\begin{matrix}P(C_4H_5)^4\\H\end{matrix}\right\}O_2$ Hydrate of tetraphosphethylammonium.

Biatomic.

$\left.\begin{matrix}Pt''\\H_2\end{matrix}\right\}O_4$ Platinic hydrate.

Triatomic.

$\left.\begin{matrix}Al_2'''\\H_3\end{matrix}\right\}O_6$ Hydrate of alumina.

Intermediate Series.

Oxy-Salts.

Neutral.

Ex.

$\left.\begin{matrix}NO_4\\K\end{matrix}\right\}O_2$ Nitrate of potash.

$\left.\begin{matrix}(NO_4)^3\\Fe_2\end{matrix}\right\}O_6$ Nitrate of sesquioxide of iron.

$\left.\begin{matrix}C_4H_3O_2\\Na\end{matrix}\right\}O_2$ Acetate of soda.

$\left.\begin{matrix}S_2O_4''\\Na_2\end{matrix}\right\}O_4$ Sulphate of soda.

$\left.\begin{matrix}(S_2O_4)''^3\\(Al_2)_2'''\end{matrix}\right\}O_{12}$ Sulphate of alumina.

$\left.\begin{matrix}C_{12}H_5O_8'''\\Ca_3\end{matrix}\right\}O_6$ Citrate of lime.

Acid.

$\left.\begin{matrix}(C_4H_3O_2)^2\\KH\end{matrix}\right\}O_4$ Biacetate of potash.

$\left.\begin{matrix}(S_2O_4)''^2\\Na_2H_2\end{matrix}\right\}O_8$ Bisulphate of soda.

$\left.\begin{matrix}(C_{12}H_5O_8)'''^3\\Na_3H_6\end{matrix}\right\}O_{18}$ Acid citrate of soda.

Negative Series.

Acids.

a. Primary acids, or *hydrated acids.*

Monatomic.

Ex.

$\left.\begin{matrix}NO_4\\H\end{matrix}\right\}O_2$ Hydrated nitric acid.

$\left.\begin{matrix}Cl\\H\end{matrix}\right\}O_2$ Hypochlorous acid.

$\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2$ Hydrated acetic acid.

$\left.\begin{matrix}C_{14}\left.\begin{matrix}H_4\\Cl\end{matrix}\right\}O_2\\H\end{matrix}\right\}O_2$ Chlorobenzoic acid.

$\left.\begin{matrix}C_{12}\begin{matrix}H_2\\(NO_4)^3\end{matrix}\\H\end{matrix}\right\}O_2$ Trinitrophenic or picric acid.

$\left.\begin{matrix}C_{20}\begin{pmatrix}H^4\\Cl_3\end{pmatrix}S_2O_4\\H\end{matrix}\right\}O_2$ Trichloro-sulpho naphthalic acid.

$\left.\begin{matrix}NH_2(C_8H_4O_4)\\H\end{matrix}\right\}O_2$ Succinamic acid.

b. Secondary bases, or anhydrous oxides.

MONATOMIC.

Ex.

$\left.\begin{matrix} K \\ K \end{matrix}\right\} O_2$ Anhydrous potash.

$\left.\begin{matrix} As(C_4H_5)' \\ As(C_4H_5)' \end{matrix}\right\} O_2$ Oxide of arsenethylium.

BIATOMIC.

$\left.\begin{matrix} Pt'' \\ Pt'' \end{matrix}\right\} O_4$ Platinic oxide.

$\left.\begin{matrix} Sb(C_4H_5)'''3 \\ Sb(C_4H_5)'''3 \end{matrix}\right\} O_4$ Oxide of stibethyle.

TRIATOMIC.

$\left.\begin{matrix} Al_2''' \\ Al_2''' \end{matrix}\right\} O_6$ Anhydrous alumina.

$\left.\begin{matrix} Bi''' \\ Bi''' \end{matrix}\right\} O_6$ Teroxide of bismuth.

BASIC.

$\left.\begin{matrix} C_4H_3O_2 \\ Pb_3 \end{matrix}\right\} O_4$ Subacetate of lead.

$\left.\begin{matrix} S_2O_4'' \\ Cu_4 \end{matrix}\right\} O_6$ Subsulphate of copper.

BIATOMIC.

$\left.\begin{matrix} S_2O_4'' \\ H_2 \end{matrix}\right\} O_4$ Hydrated sulphuric acid.

$\left.\begin{matrix} Cr_2O_4'' \\ H_2 \end{matrix}\right\} O_4$ Chromic acid.

$\left.\begin{matrix} C_4O_4'' \\ H_2 \end{matrix}\right\} O_4$ Oxalic acid.

$\left.\begin{matrix} C_8H_4O_6'' \\ H_2 \end{matrix}\right\} O_4$ Malic acid.

TRIATOMIC.

$\left.\begin{matrix} PO_2''' \\ H_3 \end{matrix}\right\} O_6$ Terhydrated phosphoric acid.

$\left.\begin{matrix} C_{12}H_5O_8''' \\ H_3 \end{matrix}\right\} O_6$ Citric acid.

b. Secondary, or anhydrous acids.

MONATOMIC.

Ex.

$\left.\begin{matrix} NO_4 \\ NO_4 \end{matrix}\right\} O_2$ Anhydrous nitric acid.

$\left.\begin{matrix} C_4H_3O_2 \\ C_4H_3O_2 \end{matrix}\right\} O_2$ Anhydrous acetic acid.

$\left.\begin{matrix} C_4H_3O_2 \\ C_{14}H_5O_2 \end{matrix}\right\} O_2$ Aceto-benzoic anhydride.

I. *Type, Water*—continued.

Positive Series.

B. Hydrocarbon Bases, or Alcohols.

a. Primary, or *alcohols, properly so called.*

Ex. MONATOMIC.

$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}O_2$ Vinic or ethylic alcohol, or hydrate of deutyle.

$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}O_2$ Allylic or acrylic alcohol, or hydrate of allyle.

$\left.\begin{matrix}C_{14}H_7\\H\end{matrix}\right\}O_2$ Benzoic alcohol.

$\left.\begin{matrix}C_{14}H_7\\H\end{matrix}\right\}O_2$ Cresylic alcohol.

BIATOMIC.

$\left.\begin{matrix}C_4H_4''\\H_2\end{matrix}\right\}O_4$ Ethylic glycol.

Intermediate Series.

Compound Ethers.

Monatomic Alcohol Radicals.

MONATOMIC ACIDS.

Ex.

$\left.\begin{matrix}C_4H_3O_2\\C_2H_3\end{matrix}\right\}O_2$ Acetate of methyle.

$\left.\begin{matrix}C_{14}H_5O_2\\C_{12}H_5\end{matrix}\right\}O_2$ Benzoate of phenyle.

$\left.\begin{matrix}Cy\\C_4H_5\end{matrix}\right\}O_2$ Cyanate of ethyle.

$\left.\begin{matrix}NH_2(C_2O_2)\\C_2H_3\end{matrix}\right\}O_2$ Carbamate of methyle, or urethylane.

$\left.\begin{matrix}C_2HO_2\\C_4\left\{\begin{matrix}H^3\\Cl_2\end{matrix}\right.\end{matrix}\right\}O_2$ Formiate of bichlorinated ethyle.

Negative Series.

ACIDS—*con.*

BIATOMIC.

$Cr_2O_4\ O_2$ Anhydrous chromic acid.

$S_2O_4\ O_2$ Anhydrous sulphuric acid.

$C_8H_4O_8\ O_2$ Anhydrous tartaric acid.

TRIATOMIC.

$\left.\begin{matrix}PO_2'''\\PO_2'''\end{matrix}\right\}O_6$ Anhydrous phosphoric acid.

TRIATOMIC.

$\left.\begin{matrix}C_6H_5'''\\H_3\end{matrix}\right\}O_6$ Glycerine.

[Perhaps grape sugar may be classed among the alcohols.]

b. Secondary, or *simple ethers*.

Ex.

$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}O_2$ Oxide of ethyle, or common ether.

$\left.\begin{matrix}C_{12}H_5\\C_{12}H_5\end{matrix}\right\}O_2$ Oxide of phenyle.

$\left.\begin{matrix}C_2H_3\\C_4H_5\end{matrix}\right\}O_2$ Oxide of methyle and ethyle.

$\left.\begin{matrix}C_4H_5\\K\end{matrix}\right\}O_2$ {Potassic alcohol or ethylate of potash.

[Cane sugar may, perhaps, come in here.]

BIATOMIC ACIDS.

Neutral.

$\left.\begin{matrix}C_4O_4''\\(C_2H_3)^2\end{matrix}\right\}O_4$ Oxalate of methyle.

$\left.\begin{matrix}C_4O_4''\\\left(\begin{matrix}C_2H_3\\C_4H_5\end{matrix}\right)\end{matrix}\right\}O_4$ Oxalate of methyle and ethyle.

$\left.\begin{matrix}S_2O_4''\\(C_4H_5)^2\end{matrix}\right\}O_4$ Sulphate of ethyle.

Acid.

$\left.\begin{matrix}S_2O_4''\\H\\C_4H_5\end{matrix}\right\}O_4$ {Acid sulphate of ethyle, or sulphovinic, or sulphethylic acid.

$\left.\begin{matrix}C_4O_4''\\H\\C_2H_3\end{matrix}\right\}O_4$ Oxalomethylic acid.

TRIATOMIC.

Neutral.

$\left.\begin{matrix}PO_2'''\\(C_2H_3)^3\end{matrix}\right\}O_6$ Neutral phosphate of methyle

$\left.\begin{matrix}C_{12}H_5O_8'''\\(C_4H_5)^3\end{matrix}\right\}O_6$ Neutral citrate of ethyle.

Acid.—Monobasic.

$\left.\begin{matrix}PO_2'''\\H\\(H)^2\end{matrix}\right\}O_6$ Phosphobimethylic acid.

I. *Type, Water*—continued.

Positive Series. | *Intermediate Series.* | *Negative Series.*

COMPOUND ETHERS—*con.*

$$\left.\begin{matrix} C_{12}H_5O_8''' \\ H \\ (C_4H_5)^2 \end{matrix}\right\} O_6$$ Citrobiethylic acid.

Bibasic.

$$\left.\begin{matrix} PO_2''' \\ H_2 \\ C_2H_3 \end{matrix}\right\} O_6$$ Phosphomonomethylic acid.

$$\left.\begin{matrix} C_{12}H_5O_8''' \\ H \\ C_4H_5 \end{matrix}\right\} O_6$$ Citromonethylic acid.

Triatomic Alcohol Radicals.

MONATOMIC ACIDS.

$$\left.\begin{matrix} C_{32}H_{31}O_2 \\ H_2 \\ C_6H_5''' \end{matrix}\right\} O_6$$ Monopalmitine.

$$\left.\begin{matrix} (C_{32}H_{31}O_2)^2 \\ H \\ C_6H_5''' \end{matrix}\right\} O_6$$ Dipalmitine.

$$\left.\begin{matrix} (C_{32}H_{31}O_2)^3 \\ C_6H_5''' \end{matrix}\right\} O_6$$ Tripalmitine.

[Glucosides may perhaps be included in the category of compound ethers.]

Aldehydes.

a. Primary.

Ex.

$\left.\begin{matrix}C_4H_3\\H\end{matrix}\right\}O_2$ Acetic aldehyde.

$\left.\begin{matrix}C_6H_3\\H\end{matrix}\right\}O_2$ Allylic aldehyde or acroleine.

$\left.\begin{matrix}\\H\end{matrix}\right\}O_2\left\{\begin{matrix}\text{Benzoic aldehyde, or oil of bit-}\\\text{ter almonds.}\end{matrix}\right.$

$\left.\begin{matrix}C_{14}H_4(NO_4)\\H\end{matrix}\right\}O_2$ Nitrobenzoic aldehyde.

$\left.\begin{matrix}C_4H_2(C_2H_3)\\H\end{matrix}\right\}O_2\left\{\begin{matrix}\text{Acetic acetone, or the ke-}\\\text{tone of the acetic series.}\end{matrix}\right.$

$\left.\begin{matrix}C_{10}H_9(C_8H_9)\\H\end{matrix}\right\}O_2\left\{\begin{matrix}\text{Valerone, or the ketone}\\\text{of the valeric series.}\end{matrix}\right.$

b. Secondary.

Compound Aldehydes.

Ex.

$\left.\begin{matrix}C_{14}H_5O_2\\C_{14}H_5O_2\end{matrix}\right\}O_2$ Salicylite of benzoyle.

$\left.\begin{matrix}S_2O_2''\\NH_4,\ C_{14}H_5\end{matrix}\right\}O_4\left\{\begin{matrix}\text{Sulphite of benzoyle and}\\\text{ammonium.}\end{matrix}\right.$

$\left.\begin{matrix}S_2O_2''\\Na,\ C_4H_3\end{matrix}\right\}O_4\left\{\begin{matrix}\text{Sulphite of acetosyle and}\\\text{sodium.}\end{matrix}\right.$

SULPHIDES.

(Also Selenides and Tellurides.)

A. Bases.

a. Primary.

Ex.

$\left.\begin{matrix}K\\H\end{matrix}\right\}S_2\left\{\begin{matrix}\text{Hydrosulphate of sulphide of po-}\\\text{tassium.}\end{matrix}\right.$

$\left.\begin{matrix}Ba\\H\end{matrix}\right\}S_2\left\{\begin{matrix}\text{Hydrosulphate of sulphide of}\\\text{barium.}\end{matrix}\right.$

Sulpho-Salts.

Ex.

$\left.\begin{matrix}Cy\\K\end{matrix}\right\}S_2$ Sulphocyanide of potassium.

$\left.\begin{matrix}C_4H_3O_2\\Na\end{matrix}\right\}S_2$ Thiacetate of soda.

Sulpho-Acids.

a. Primary.

Monatomic.

Ex.

$\left.\begin{matrix}Cy\\H\end{matrix}\right\}S_2$ Hydrosulphocyanic acid.

I. *Type, Water*—continued.

Positive Series.

A. Bases—*con.*

$\left.\begin{matrix} NH_4 \\ H \end{matrix}\right\} S_2 \left\{\begin{matrix} \text{Hydrosulphate of sulphide of} \\ \text{ammonium.} \end{matrix}\right.$

$\left.\begin{matrix} N(C_{12}H_5)H_3 \\ H \end{matrix}\right\} S_2$ Hydrosulphate of aniline.

b. Secondary, or metallic sulphides.

Ex.

$\left.\begin{matrix} K \\ K \end{matrix}\right\} S_2$ Protosulphide of potassium.

$\left.\begin{matrix} Pt'' \\ Pt'' \end{matrix}\right\} S_4$ Bisulphide of platinum.

$\left.\begin{matrix} Fe_2{}''' \\ Fe_2{}''' \end{matrix}\right\} S_6$ Sesquisulphide of iron.

$\left.\begin{matrix} Bi''' \\ Bi''' \end{matrix}\right\} S_6$ Tersulphide of bismuth.

$\left.\begin{matrix} Sb(C_2H_3)^4 \\ Sb(C_2H_3)^4 \end{matrix}\right\} S_2$ Sulphide of stibmethylium.

$\left.\begin{matrix} Bi(C_4H_5) \\ Bi(C_4H_5) \end{matrix}\right\} S_4$ Sulphide of bismuthethyle.

Intermediate Series.

Sulpho-Salts—*con.*

$\left.\begin{matrix} C_2S_2{}'' \\ Pb_2 \end{matrix}\right\} S_4 \left\{\begin{matrix} \text{Sulphocarbonate of sulphide} \\ \text{of lead.} \end{matrix}\right.$

$\left.\begin{matrix} AsS_2{}''' \\ K_3 \end{matrix}\right\} S_6 \left\{\begin{matrix} \text{Tribasic sulpharseniate of} \\ \text{sulphide of potassium.} \end{matrix}\right.$

Negative Series.

Sulpho-Acids—*con.*

$\left.\begin{matrix} C_4H_3O_2 \\ H \end{matrix}\right\} S_2$ Thiacetic acid.

Biatomic.

$\left.\begin{matrix} C_2S_2{}'' \\ H_2 \end{matrix}\right\} S_4$ Hydrosulphocarbonic acid.

b. Secondary, or anhydrous sulphides.

Ex.

$\left.\begin{matrix} C_4H_3O_2 \\ C_4H_3O_2 \end{matrix}\right\} S_2$ Sulphide of acetyle.

$\left.\begin{matrix} C_{14}H_5 \\ C_{14}H_5 \end{matrix}\right\} S_2$ Sulphide of benzoyle.

$\left.\begin{matrix} C_2S_2 \\ C_2S_2 \end{matrix}\right\} S_4 \left\{\begin{matrix} \text{Sulphocarbonic acid or bisul-} \\ \text{phide of carbon.} \end{matrix}\right.$

$\left.\begin{matrix} As\,S_2{}''' \\ As\,S_2{}''' \end{matrix}\right\} S_6$ Sulpharsenic acid.

B. Sulphur Alcohols.

a. Primary, or mercaptans.

Ex.

$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2$ Hydrosulphate of ethyle.

$\left.\begin{matrix}C_{10}H_{11}\\H\end{matrix}\right\}S_2$ Hydrosulphate of amyle.

b. Secondary, or hydrosulphuric ethers.

$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}S_2$ Sulphide of ethyle.

$\left.\begin{matrix}C_6H_5\\C_6H_5\end{matrix}\right\}S_2$ {Sulphide of allyle, or oil of garlic.

$\left.\begin{matrix}C_4H_5\\Hg\end{matrix}\right\}S_2$ Ethylic mercaptide.

Sulphur Aldehydes.

a. Primary.

Ex.

$\left.\begin{matrix}C_4H_3\\H\end{matrix}\right\}S_2$ Hydrosulphate of acetosyle.

$\left.\begin{matrix}C_{14}H_5\\H\end{matrix}\right\}S_2$ Sulphobenzole.

b. Secondary.

Compound Sulphur Ethers.

Ex.

$\left.\begin{matrix}C_2H_3\\Cy\end{matrix}\right\}S_2$ Sulphocyanide of methyle.

$\left.\begin{matrix}C_6H_5\\Cy\end{matrix}\right\}S_2$ {Sulphocyanide of allyle, or oil of mustard.

$\left.\begin{matrix}C_4H_3O_2\\C_4H_5\end{matrix}\right\}S_2$ Thiacetate of ethyle.

Compound Sulphur Aldehydes.

$\left.\begin{matrix}C_{14}H_7\\Cy\end{matrix}\right\}S_2$ Sulphocyanide of benzoyle.

$\left.\begin{matrix}C_6H_5\\H\\Cy_2\end{matrix}\right\}S_4.$

II. *Type, Hydrochloric Acid,* n Cl H.

CHLORIDES.

(Bromides, Iodides, Fluorides).

Positive Series.

BASIC CHLORIDES.

a. Primary, or *metallic chlorides.*

MONATOMIC.

Ex.

NaCl. Chloride of sodium.
AgCl. Chloride of silver.
$Sn(C_4H_5)Cl$. Chloride of stannethyle.
NH_4Cl. Chloride of ammonium.
$NH_3(C_4H_5)$ Cl. Chloride of ethyl-ammonium.
$N(C_2H_2Pt)$ H_3 Cl. Chloride of platoso methylammonium.

BIATOMIC.

Pt Cl_2 Bichloride of platinum.

TRIATOMIC.

Fe_2Cl_3 Sesquichloride of iron.
$AuCl_3$ Terchloride of gold.

Intermediate Series.

MULTIPLE CHLORIDES.

$\left.\begin{matrix}K\\ Pt''\end{matrix}\right\}Cl_3$ Chloroplatinate of potash.

$\left.\begin{matrix}N(C_{12}H_5)H_2Hg\\ Hg_2\end{matrix}\right\}Cl_3$ {Chloro-mercurate of aniline.

$\left.\begin{matrix}N(C_2H_3)H_3\\ Au'''\end{matrix}\right\}Cl_4$ {Chloro-aurate of methyl-ammonium.

Negative Series.

ACID CHLORIDES.

a. Primary.

MONATOMIC.

Ex.

Cy. Cl. Chloride of cyanogen.
$C_4H_3O_2$,Cl. Chloride of acetyle.
$C_{14}H_4(Cl)O_2$,Cl. Chloride of chlorobenzoyle.
$N(C_{12}H_3O_6)(C_{12}H_5)$,Cl. Chloride of phenyl-aconityl ammonium, or of aconitanilic acid.

BIATOMIC.

C_2O_2,Cl_2 Phosgene, chloride of carbonyle.
Cr_2O_4,Cl_2 Chloride of chromyle, or chlorochromic acid.

TRIATOMIC.

P.Cl_3 Terchloride of phosphorus.
PO_2Cl_3 Chloride of phosphoryle, or oxychloride of P.
PS_2Cl_3 Chloride of sulphophosphoryle.
PCl_2.Cl_3 Chloride of chlorophosphoryle, or pentachloride of P.
Cy_3Cl_3 Chloride of cyanuryle (solid chloride of Cy.)

Alcoholic Chlorides.

a. Primary, or *hydrochloric ethers.*

Ex.

C_2H_3,Cl. Chloride of methyle.

$C_{12}H_5,Cl$. Chloride of phenyle.

$C_6H_5O_2,Cl$. Chloride of glyceryle or epichlorhydrine.

$\left.\begin{matrix}C_6H_5O_2\\H\end{matrix}\right\}Cl_2$ Dichlorhydrine.

$\left.\begin{matrix}C_6H_5O_2\\H\\H\end{matrix}\right\}\begin{matrix}O\\Cl\end{matrix}$ Oxychloride of glyceryle and hydrogen.

$\left.\begin{matrix}C_6H_5O_2\\C_4H_3O_2\\H\end{matrix}\right\}\begin{matrix}O\\Cl\end{matrix}$ Oxychloride of glyceryle, acetyle, and hydrogen.

Aldehydic Chlorides.

a. Primary.

Ex. Monatomic.

C_4H_3,Cl. Chloride of aldehydene.

C_6H_5,Cl. &c.

Biatomic.

$\left.\begin{matrix}C_4H_3\\H\end{matrix}\right\}Cl_2$ Chloride of ethylene.

D

$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}Cl_2$, &c.

$\left.\begin{matrix}C_{14}H_5\\H\end{matrix}\right\}Cl_2$ Chlorobenzole.

II. *Type, Hydrochloric Acid*—continued.

CYANIDES.

Positive Series.

BASIC CYANIDES.

a. Primary metallic cyanides.

Ex.

KCy Cyanide of potassium.

$\left.\begin{matrix}Fe\\M_2\end{matrix}\right\}Cy_3$ Ferro-cyanides.

$\left.\begin{matrix}Fe_2'''\\M_3\end{matrix}\right\}Cy_6$ Ferri-cyanides.

ALCOHOLIC CYANIDES.

a. Primary hydrocyanic ethers, or *nitryles.*

Ex.

Cy,C_2H_3 Cyanide of methyle, or aceto-nitryle.

$Cy,C_{12}H_5$ Cyanide of phenyle, or benzo-nitryle.

$CyC_{12}H_4(NO_4)$ Cyanide of nitrophenyle, or nitrobenzo-nitryle.

ALDEHYDIC CYANIDES.

a. Primary.

Intermediate Series.

Negative Series.

ACID CYANIDES.

a. Primary.

Ex.

$Cy,C_{14}H_5O_2$ Cyanide of benzoyle.

CyCy Free cyanogen.

Type, Ammonia, $n\ N\left\{\begin{matrix}H\\H.\\H\end{matrix}\right.$

NITRIDES.

(Phosphides, Arsenides, Antimonides.)

Basic Nitrides.

a. Primary.

Ex.
$\left.\begin{matrix}K\\H\\H\end{matrix}\right\}N$ Amide of potassium.

b. Secondary.

c. Tertiary.

Ex.
$\left.\begin{matrix}K\\K\\K\end{matrix}\right\}N$ Nitride of potassium.

$\left.\begin{matrix}C_2\\C_2\\C_2\end{matrix}\right\}N$ Nitride of copper.

Alcoholic Nitrides.

a. Primary.

Ex.
$\left.\begin{matrix}C_2H_3\\H\\H\end{matrix}\right\}N$ Methylamine.

Amide Salts.

Ex.
$\left.\begin{matrix}C_{14}H_5O_2\\Hg\\H\end{matrix}\right\}N$ Benzamidate of mercury.

Alcalamides.

a. Secondary.

Monalcalamides.

Ex.
$\left.\begin{matrix}C_4H_3O_2\\C_4H_5\\H\end{matrix}\right\}N$ Ethyl-acetamide.

Acid Nitrides.

a. Primary.

Monamides.

Ex.
$\left.\begin{matrix}C_4H_3O\\H\\H\end{matrix}\right\}N$ Acetamide.

$\left.\begin{matrix}C_4H_3O_4\\H\\H\end{matrix}\right\}N$ Glycocoll, or sugar of gelatine.

$\left.\begin{matrix}C_2N\\H\\H\end{matrix}\right\}N$ Cyanamide.

$\left.\begin{matrix}C_{12}H_5S_2O_4\\H\\H\end{matrix}\right\}N$ Sulphophenylamide.

Diamides.

$\left.\begin{matrix}C_4O_4''\\H_2\\H_2\end{matrix}\right\}N_2$ Oxamide.

Type, Ammonia—continued.

Positive Series.

ALCOHOLIC NITRIDES—*con.*

$\left.\begin{matrix} C_{12}H_5 \\ H \\ H \end{matrix}\right\} N$ Phenylamine, aniline.

b. Secondary.

$\left.\begin{matrix} C_2H_3 \\ C_2H_3 \\ H \end{matrix}\right\} N$ Bimethylamine.

$\left.\begin{matrix} C_2H_3 \\ C_4H_5 \\ H \end{matrix}\right\} N$ Methyl-ethylamine.

c. Tertiary.

$\left.\begin{matrix} C_2H_3 \\ C_2H_3 \\ C_2H_3 \end{matrix}\right\} N$ Trimethylamine.

$\left.\begin{matrix} C_2H_3 \\ C_4H_5 \\ C_{10}H_{11} \end{matrix}\right\} N$ Methyl-ethyl-amylamine.

ALDEHYDIC NITRIDES.

a. Primary.

MONAMINES.

Ex.

$\left.\begin{matrix} C_4H_3 \\ H \\ H \end{matrix}\right\} N$ Acetosylamine.

Intermediate Series.

ALCALAMIDES—*con.*

$\left.\begin{matrix} Cy \\ C_2H_3 \\ H \end{matrix}\right\} N$ Methylo-cyanamide.

DIALCALAMIDES.

$\left.\begin{matrix} C_4O_4'' \\ (C_2H_3)^2 \\ H_2 \end{matrix}\right\} N_2$ Bimethyl-oxamide.

$\left.\begin{matrix} C_2S_2'' \\ (C_{12}H_5)^2 \\ H_2 \end{matrix}\right\} N_2$ Biphenylosulpho-carbamide.

$\left.\begin{matrix} C_{12}H_5O_8''' \\ (C_{12}H_5)^2 \\ H \end{matrix}\right\} N_2$ Biphenylo-citrimide.

$\left.\begin{matrix} C_2O_2'' \\ C_{12}H_5 \\ H_3 \end{matrix}\right\} N_2$ Phenyl-urea.

b. Tertiary.

MONALCALAMIDES.

$\left.\begin{matrix} C_4H_3O_2 \\ C_4H_3O_2 \\ C_4H_5 \end{matrix}\right\} N$ Ethylobiacetamide.

$\left.\begin{matrix} Cy \\ C_2H_3 \\ C_4H_5 \end{matrix}\right\} N$ Methyl-ethylo-cyanamide.

Negative Series.

ACID NITRIDES—*con.*

$\left.\begin{matrix} C_2O_2'' \\ H_2 \\ H_2 \end{matrix}\right\} N_2$ Carbamide, urea.

$\left.\begin{matrix} C_2O_2'' \\ C_4H_3O \\ H_3 \end{matrix}\right\} N_2$ Acetyl-urea.

TRIAMIDES.

$\left.\begin{matrix} C_{12}H_5O_8''' \\ H_3 \\ H_3 \end{matrix}\right\} N_3$ Citramide.

$\left.\begin{matrix} Cy_3 \\ H_3 \\ H_3 \end{matrix}\right\} N_3$ Melamine, or melam.

b. Secondary.

MONAMIDES.

$\left.\begin{matrix} C_4H_3O_4 \\ C_{14}H_5O_2 \\ H \end{matrix}\right\} N$ Hippuric acid, or nitride of glycocoll, benzoyle, and hydrogen.

$\left.\begin{matrix} C_8H_4O_4'' \\ H \end{matrix}\right\} N$ Succinimide.

c. Tertiary.

MONAMIDES.

$\left.\begin{matrix} C_{12}H_5S_2O_4 \\ C_{14}H_5O_2 \\ C_4H_3O_2 \end{matrix}\right\} N$ Nitride of sulphophenyle, benzoyle, and acetyle.

DIAMINES.

$\left.\begin{matrix}(C_{14}H_5O_2)^3 \\ H_3\end{matrix}\right\}$ N^2 Salhydramide.

b. Secondary.

c. Tertiary.

UNDETERMINED NITRIDES, OR NATURAL VEGETO-ALKALIES.

$\left.\begin{matrix}C_8H_4O_4'' \\ C_{12}H_5\end{matrix}\right\}$ N Phenylo-succinimide.

$\left.\begin{matrix}C_2O_2'' \\ C_2H_3\end{matrix}\right\}$ N Cyanate of methyle, or methylo-carbonimide.

$\left.\begin{matrix}(C_8H_4O_4)'' \\ C_{12}H_5S_2O_4\end{matrix}\right\}$ N Nitride of succinyle, and of sulphophenyle.

PO_2''' N Biphosphamide, or nitride of phosphoryle.

N, N Free nitrogen, or nitride of nitrogen.

NO_2, N Protoxide of nitrogen, or nitride of azotyle.

B, N Boramide, or nitride of boron.

DIAMIDES.

$\left.\begin{matrix}C_8H_4O_4'' \\ (C_{14}H_5O_2)^2 \\ (C_{12}H_5S_2O_4)^2\end{matrix}\right\}$ N_2 Biamide of succinyle, of bibenzoyle, and of bisulphophenyle.

Type, Hydrogen, $n\left.\begin{matrix}H \\ H\end{matrix}\right\}$.

POSITIVE, OR BASIC METALS.

a. Primary, or *metallic hydrides.*

MONATOMIC.

Ex.
HCu_2 Hydride of copper.

TRIATOMIC.

H_3Sb''' Hydride of antimony.

INTERMEDIATE METALS.

Cyanides of metals, nitryles, and other bodies, already included in other classes, come in here. Chlorides, oxides, sulphides, &c., may likewise be considered as intermediate metals.

NEGATIVE, OR ACID METALS.

a. Primary, or *acid hydrides.*

MONATOMIC.

H, NO_4 Nitrous acid, or aldehyde of nitric acid.

H, Cl Hydrocloric acid, or aldehyde of hypochlorous acid.

Type, Hydrogen—continued.

Positive Series.

POSITIVE, or BASIC METALS—*con.*

b. Secondary, or *metals proper.*

α. Simple metals—

KK Potassium.
$Al_2'''Al_2'''$ Aluminium.

β. Conjugate metals—

$\left.\begin{matrix}(C_2H_3)^2\\(C_2H_3)^2\end{matrix}\right\}As_2$ Cacodyle.
C_4H_5 Sn Stannethyle.
$(C_4H_5)^3$ Bi Bismuthethyle.

ALCOHOL METALS.

a. Primary, or *alcoholic hydrides.*

Ex.

H, C_2H_3 Hydride of methyle, or marsh gas.
H, $C_{12}H_5$ Hydride of phenyle.
H, C_4H_4Cl Hydride of chlorethyle.
H, $C_{12}H_2Cl_3$ Trichlorophenyle.
H, $C_{14}H_6(NO_4)$ Nitrotoluole.

Intermediate Series.

Negative Series.

NEGATIVE, or ACID METALS—*con.*

H, Cy Hydrocyanic acid, or aldehyde of cyanic acid.
H, $C_4H_3O_2$ Acetic aldehyde, or hydride of acetyle.
H, P Aldehyde of hypophosphorous acid.

BIATOMIC.

H_2S Aldehyde of hyposulphurous acid, or sulphide of hydrogen.

TRIATOMIC.

H_3P Aldehyde of phosphorous acid.

b. Secondary, or *alcoholic metals.*

(improperly called alcoholic radicals.)

Ex.

a. C_2H_3, C_2H_3 Methyle.
$C_{10}H_{11}, C_{10}H_{11}$ Amyle.

β. C_4H_5, C_8H_9 Ethylo-butyle.
C_2H_3, Zn Zinc-methyle.

ALDEHYDIC METALS.

a. Primary, or *aldehydic hydrides.*

Ex.

H, C_4H_3 Ethylene, or olefiant gas.
$H, C_{60}H_{59}$ Melene.

b. Secondary.

b. Secondary, or *metalloids.*

Ex.

All the simple bodies called metalloids—sulphur, phosphorus, chlorine, &c.; cyanogen; benzoyle, &c.

PHYSICAL CHEMISTRY.

CRYSTALLOLOGY.

I. CRYSTALLOGRAPHY.

Generalities.—Of crystals. Faces; kinds of faces which occur in natural crystals; simple and compound forms; dominant and secondary forms. Edges; kinds of edges. Angles; kinds of angles. Rule for determining the number of faces, edges, and of angles of a form.

Axes; kinds of axes—co-ordinate axes, morphological axes, crystallographic axes. Upright position of a crystal. Principal and secondary crystallographic axes. Sections; principal sections; projections. Classification of the morphological axes of forms, according to the relative symmetry of the principal sections of the different systems of axes.

Principal types of form; uniaxial and polyaxial forms; comparative symmetry of forms. Relations between the different forms which the same substance may assume; derivation—truncation and pointing of angles—truncation and bevelment of edges; alternate or diagonal positions. Law of symmetry; progression; zones. Exception to the law of symmetry—hemihedrism. Anomalies of symmetry—twin crystals; hemitropes, cruciform, macles, and circular macles.

Relation of the faces of a crystal to its crystallographic axes—parameters. Law of multiple proportion observed between the parameters of the series of faces which occur in the forms assumed by any given body; indices. Notation of faces.

Classification.—Classification of crystalline forms into seven systems according to the number, angles of intersection, and relative lengths of the crystallographic axes.

I. TRIMETRICAL,

(or forms in which three crystallographic axes are assumed).

A. Orthohedric,

(or straight forms, the axes of which intersect at right angles).

1. Isometrical (monometrical, cubical, octohedral, or regular).
2. Monodimetric (tetragonal, quadratic, prismatic, or pyramidal).
3. Anisometric (trimetric, orthorhombic, or rhombic).

B. Clinohedric.

(or leaning forms, with one or more axes intersecting at oblique angles).

4. Monoclinic, or singly leaning prismatic system. (Augitic, clinorhombic or oblique prismatic system).

5. Diclinic, or doubly leaning prismatic system (diclinrhombic system).

6. Triclinic, or trebly leaning prismatic system (anorthic or doubly oblique prismatic system).

II. TETRAMETRICAL.

(or forms in which four crystallographic axes are assumed).

7. HEXAGONAL or RHOMBOHEDRAL system.

DESCRIPTION.—Character of the axes of each system; fundamental form and progression of each system. Simple holohedral and hemihedral forms of each system. Derivation of the simple forms from the respective fundamental forms of each system: *a.* by truncatures on the angles; *b.* by truncatures on the edges; *c.* by bevelment of the edges; and *d* by pointing of the angles.

Homogeneous combinations, or compounds of two simple forms; heterogeneous or mixed combinations.

Twins of each system: *a.* hemitropes; *b.* cruciform macles; *c.* circular macles.

II. CRYSTALLO-PHYSICS.

DENSITY.—Comparative density of bodies in different states. Relation between crystalline form and density.

COHESION.—Clivage; origin of the word; the facility of clivage not equal in every direction; secondary clivages; relation between the crystalline system and the number and relative facilities of clivages; solid of clivage.

Hardness; scales of hardness; relative hardness of the different faces of compound forms, and of the different faces of clivage. Action of solvents on the faces of crystals.

Fracture of crystals, and of crystalline bodies.

OPTICAL PROPERTIES.—Transparency. Simple refraction; index of refraction; dispersive power of crystals. Double refraction in crystals; relative position of the two images; law followed by the ordinary ray. Relation between the crystalline form and double refraction—crystals with one optic axis; position of the axis in uniaxial crystals; position of the axes in biaxial crystals. Positive and negative double refraction; measure of the angle between the optic axes,

Polarization of light by reflection; angle of polarization in different crystals; analogy between double refraction and polarization. Polarization of light by the tourmaline; use of the tourmaline to discover the existence of a double refractive power in crystals. Black lines and coloured rings seen in crystals by polarized light. Relation between the black lines and coloured rings and the crystalline form; use of the relative diameters of coloured rings to distinguish hemitropes. Rotatory polarization in quartz; relation between the rotatory power and hemihedrism. Hyperbolic fringes of M. Delezenne. Pasteur's observations on the relation between rotatory polarization and the dissymmetry of tartaric acid.

Lamellar polarization; explanation which it affords of certain phenomena of polarization in the regular system, and of the apparent existence of two axes in certain uniaxial crystals.

Lustre; kinds of lustre; degrees of lustre. Colour; scales of colour employed in the description of bodies. Streak. Opalescence, Fluorescence, Irisation, Asteries, Polychroism.

ELASTICITY.—Elastic properties of crystals discovered by means of vibration of plates; disposition of the nodal lines. Relation between the crystalline form and elasticity—axes of elasticity. Comparative acoustic properties of the crystals of each system.

THERMAL PROPERTIES.—Influence of crystalline form upon specific and latent heat. Influence of crystalline form upon the relative power of conducting heat in different directions. Expansion of crystals. Grailich's law of conservation of zones.

Propagation of radiant heat in crystals.

ELECTRICAL AND MAGNETICAL RELATIONS OF CRYSTALS.—Development of electricity in crystals; classification of crystalline bodies into positive and negative according as they produce one or the other kind of electricity. Polar electricity of crystals; electrical axes; terminal and central poles of electrical axes. Influence of form upon electrical conductibility.

Phosphorescence of crystalline bodies.

Magnetic polarity of certain minerals; relation between magnetic polarity and crystalline form. Diamagnetic properties of certain crystals.

III. CRYSTALLO-CHEMISTRY.

Influence of chemical composition upon the symmetry of form of bodies. Crystalline forms of the simple bodies. Crystallo-chemical classification of compound bodies.

Heteromorphism, dimorphism, trimorphism. Isomorphism, homæomorphism, isomeromorphism, heteromeric isomorphism, polymeric isomorphism. Comparison between the indices of crystalline series of isomorphic groups.

IV. CRYSTALLOGENY.

Methods by which crystals may be formed. 1. By the wet way, that is, by solution of the substance in water, or other fluid. 2. By the dry way—*a.* by simple fusion and cooling; *b.* by the agency of fluxes; *c.* by direct sublimation, by indirect sublimation, or by transport; and *d.* by internal molecular changes induced by heat, vibration, &c.

Imperfections of crystals: unequal extension of faces, monstrosities, obliterations, imperfections of surface, striae. Twins:

metagenic and paragenic twins. Combinations of heterogeneous crystals; paragenesis of heterogeneous crystals.

Growth of crystals, size of crystals, structure of crystalline groups. When the growth is uniform or normal in all three dimensions, the structure of aggregated masses of crystals is granular (saccharoidal, &c.); when the growth is chiefly according to two dimensions, the structure is lamellar (orthoclase, sparry, scaly, schistoid, &c.); when the growth is chiefly according to one dimension, the structure is baccillary or fibrous (acicular, radiated, felted, &c.).

Circumstances which influence the production, growth, or form of crystals. Density of solution, compression, mass of solution or melted matter, vibration; form of vessel, action of crystals of the same kind or of a different kind; action of light; evaporation, temperature of dissolution, joint action of pressure and temperature; presence of isomorphic salts having analogous composition; isomorphic compounds of a different chemical composition; presence of clinic compounds in the mother liquors of orthically crystallizing bodies, and conversely of orthic compounds in those of clinically crystallizing bodies; voltaic currents; action of magnetism.

Nature of crystallizing force. The crystalline state the normal condition of solid matter; the amorphous and glassy states, as well as the state of temper in steel, &c., are states of tension. Proofs of the correctness of this view afforded by the processes of devitrification, metamorphism of rocks by heat without fusion, effects of long-continued vibration upon bars of metal, &c.

Views regarding the molecular constitution of matter. The crystalline molecules not necessarily identical with the ultimate molecules; they are rather to be considered as proximate compounds of ultimate particles in much the same way as the proximate constituents of animals and plants are each made up of certain ultimate particles. Haüy's theory of decrements. Application of this theory to account for the modification of crystals: decrements on the edges; decrements on the angles; mixed decrements. External isomorphism does not necessarily involve identity of integrant or crystalline molecules. A substance may even have two distinct integrant molecules, one of which is intimately connected with the chemical constitution of the body, while the other merely belongs to it in its crystallized state. The circumstance that a substance may exhibit the phenomenon of circular polarization in the solid state, and not in solution, supports this view. Delafosse's use of the preceding doctrine to explain hemihedrism. Causes which appear to produce this kind of dissymmetry.

Pseudomorphites or imitative forms—*a.* those formed by the loss of one or more constituents; *b.* those formed by the gain of one or more constituents; *c.* those formed by the removal and addition of constituents; *d.* those formed by a total substitution of material.

Comparison between the artificial methods of producing crystals, and those by which it would appear that natural ones have been formed.

History of Crystallography.—The predecessors of Haüy—Gulielmini, Bergmann, Romé Delisle. Crystallographic system of Haüy. Weiss' introduction of the mode of considering crystals in reference to their axes, and his theory of hemihedrism. Different systems of nomenclature which have been proposed.

THERMO-CHEMISTRY.

Influence of chemical composition upon the dilatation of solids and liquids. Changes of density which accompany chemical changes. Maximum density of saline solutions.

Fusion and solidification. Ebullition and evaporation; distillation and sublimation; distinction between gases and vapours. Relation between the boiling points of homologous series. Influence of salts in solution upon the boiling point of liquids; boiling point of saturated solutions; freezing point of saline solutions. Latent heat of fusion; latent heat of gases; latent heat of solution, and of dilution; relation between the chemical composition of a body and its latent fusion and evaporation heat. Relation between the density of gases and vapours and their chemical equivalent. Tension of vapours at different temperatures; tension of the vapour of mixed fluids; tension of the vapour of saline solutions; influence which the addition of a salt to a mixture of two fluids exerts upon the tension of the vapour.

Specific heat of bodies; relation established between the specific heat and chemical equivalents of bodies.

Heat of combination. Thermo-chemical laws.

Calorimetry. Different methods employed to determine the specific, latent, and combination heat of bodies.

Theories of combustion. Nature of flame.

Chemical relations of radiant heat.

CHEMICAL RELATIONS OF LIGHT.

Combinations and decompositions affected by the aid of light. Molecular changes induced in bodies by the action of light, and by which their chemical properties are altered. The photographic image. Chemical effects of the different coloured rays of the solar spectrum. Effects of solutions of

different substances upon the chemical action of the solar spectrum. Influence of solutions and gases and vapours upon the character and position of Frauenhofer's lines and upon the refrangibility of light—researches of Bunsen and Kirchhoff and of Mr. Stokes. The refractive and dispersive powers of bodies in relation to chemical composition.

ELECTRO-CHEMISTRY,

Chemical sources of electricity. Chemical action of voltaic electricity. Chemical action of electrical discharges. Allotropism produced by electrical discharges—ozone. Laws of electro-chemical decomposition; the chemical powers of a current the same at all points of the circuit; law of electrolytic decomposition for binary compounds, neutral salts of protoxide bases, acid and basic salts, salts of sesqui oxides, &c.; the law depends upon the electro-negative element; law of the definite action of the current upon electrolytes, and its application to cases where the current traverses a mixture of electrolytes; physical conductibility of liquids; restriction of Faraday's law of the electrical equivalents; theories of electro-chemical decomposition. Electro-chemical classification.

On the voltaic couple and the various forms of the voltaic battery.

MOLECULAR ACTIONS.

Relative compressibility of different liquids. Effect of pressure upon the point of solidification of fused bodies. Capillary phenomena; the diminution of the capillary height of fluids as the temperature increases may serve as a measure of cohesion; influence of chemical composition on the capillary height. Mixture of different liquids; diffusion of liquids; phenomena exhibited at the surface of contact of liquids which do not mix; the wetting of solids by liquids; solution; capillary affinity; osmotic currents; dialysis. Influence of chemical composition upon the flow of liquids through capillary tubes, and elastic and rigid pipes. Molecular structure of bodies; tempering and annealing. Changes effected by repeated fusions. Effect of heat and pressure in modifying the molecular structure and chemical properties of bodies; properties of precipitates produced in solutions of different degrees of concentration and at different temperatures. Effect of vibration, the passage of electrical currents, unequal pressure, &c., upon molecular structure.

General considerations upon the nature of chemical affinity. Influence of cohesion upon chemical affinity; relation between cohesion and affinity. The change of volume accom-

panying chemical combination and the thermic effects resulting compared with the compressibility of bodies and the decrease of capillary height in liquids on being heated, may afford us an approximate measure of the comparative forces which act in cohesion and chemical combination. The atomic theory. Atomic volume. Isomerism. Relation betwen isomerism and isomorphism. Allotropism.

CHEMISTRY IN RELATION TO PHYSIOLOGY.

Relation between the form and chemical composition of plants. Comparative chemical composition of different natural families of plants.

Chemical changes which take place during the growth of plants. Decay.

Comparative chemical composition of the different tissues and fluids of animals.

Chemical changes which take place during the life of animals. Chemical phenomena of death.

EVENING COURSE OF PUBLIC LECTURES.

On the Elements of Chemistry, and on the use of Chemistry in the Arts.

ZOOLOGY.

Professor, J. R. Kinahan, F.L.S.

I. Physiological.

Introduction.

Organized being: definition of term. Necessary conditions of Organized Existence. Functions of Organized Life. Necessary connexion between Function and Organs. Interchange of Function between different Organs. Simple Organs. Compound Organs. Complex Organs. Simple, Complex, and Compound Functions. The same Organs may perform several distinct Functions at the same or different periods of the Animal's existence. *Organs in different Animals may be either identical in Structure and Position, or else only similar in appearance. Organs identical in structural relations may perform different Functions in different Animals.* Homology, or *structural* identity. Analogy, or *functional* similarity. Limits of these. Importance of a correct and definite idea of their meaning. Homomorph. Homotype.

The two phases of Organized Existence. The Plant, or Phyton. The Animal, or Zoon. Their relations, agreements, and contrasts. Their distinctness in mode of growth, origin, composition, and development. *Many of the Forms and Functions of the Plant found to exist in the Animal, along with certain Functions and Forms peculiar to Animals.*

Functions of Animal Life twofold, viz., *either those held in common with Plants, or those peculiar to Animals: the former called, therefore, Vegetative; the latter, Animal.*

Vegetative Functions in Animal Existences considered in their most complete development:—

I. Nutrition and its Organs. Objects of Function fourfold. Its operations divisible into—Prehension and Mastication of Food; Organs thereunto subservient. Assimilation of Nutrition, and its Organs. Respiration.—Its Types: Atmospheric and Aquatic. Atmospheric Respiration:—Tracheæ; Cutaneous Covering (pores?); Lungs; Aquatic Respiration—Aquiferous Vessels; Skin (stomates); Gills or Branchiæ. Circulation and Absorption: Organs. Excretion. Secretion.

II. Increase. *Increase by similar Cells.* The simple Cell: its modes of increase. Gemmation. Fission, Free Cell-Growth. Fibrillation of Tissues.

III. Reproduction. Increase by dissimilar Cells. Conjugation. Viviparous, Oviparous, Ovo-viviparous Animals. Parthenogenesis, Metagenesis, Agamogenesis. Many of these peculiar to the Animal.

Development.—Changes undergone during growth of Animal. Metamorphosis, complete, incomplete. Ammocœte Tadpole, Larva, Zoe, Cercaria. Alternation of Generations.

ANIMAL FUNCTIONS.

IV. Motion. Difference between Animal and Vegetable Motions. The latter met with in Animals. The Animal Skeleton or supporting system of Organs. Exoskeleton (tegumentary and cutaneous systems; systems of appendages, &c.). Endoskeleton. Mesoskeleton. Muscular or true Motive System. Sinews. Tendons.

V. Sensation and Direction. Sensatory Centres, or Nervous Ganglia. Sensatory directive Filaments, or Nerves.

Special arrangements of each of these in the great Primary Groups, the characters drawn from Functions of Sensation being the best marked.

Differentiation of Organs or Specialization of Function. Laws of Specialization.

1. The functional character of Organs is *common;* the mode in which it is manifested varies with the general Type (Archetype) on which the being is constituted.

2. When different functions are highly specialized, the general structure retains more or less the primitive community of the functions which originally characterized it.

3. The Typical structure of a Group being given, the different habits of its component individuals are provided for entirely by the modification in form, structure, or place of the Organs Typically belonging to the Group.

Examination of the application of these laws.

Existence of Types. Explanation of term Type. The great primary Animal Types or Holotypes: Vertebrata, Mollusca, Articulata, Radiata, Acrita. All Animals known referrible to one or other of these. Distinctness and stability of these Types. Examples of them. Secondary or sub-Types: Class, Order, sub-Order, Family, Genus, sub-Genus, Species. *Groups founded on a series of characters drawn from the Arrangement of Organs.* Apparent interchange or rather gradations of characters in these Groups. Limited variation of Typical characters in each Group, &c. Consideration of these. Explanation of terms *higher* and *lower,* as applied to Groups. *Those Groups in which greatest differentiation takes place called highest; therefore, highest Animals have most complex Functions, and vice versâ.*

II. CLASSIFICATION.

Intentions, necessity, and objects of Classification. Systems of Classification. *The Artificial, or that dependent on accidental agreement of characters arbitrarily chosen.* Sys-

tems of Aristotle, Linnæus, Ray. Early Systems of Hunter. *Natural System, or that dependent on presence or absence of characters having a natural connexion and dependence on each other.* Systems of Hunter, Cuvier, Owen, and the moderns.

General definitions of Holotypes, Vertebrata, Mollusca, Articulata, Radiata, Acrita.

Differentiation of Organs in these. Nervous System undetected in Acrita.

The following System of analogous Organs present in most Animals :—A Tegumentary or Protective. A Skeleton or Supporting. A Muscular or Motive. A Nutritive, or Assimilative and Circulatory. A Reproductive. A Sensatory and Directive. All more or less highly developed, and all arranged on different plans in each Type.

Relations between the several systems of organs constant in the same Type, so that the general arrangement known in one, we can reconstruct the general plan of the entire. *Harmony of organs.* Value of this law in Palæontology.

Modification of Types due to accidental disturbing causes. Races or Animals of cultivation. Man and his races. Domesticated races. Alteration of Type not a necessary consequence of cultivation. Variety or change due to accidental natural causes generally limited to restricted districts. Tendency to revert to original Type.

VERTEBRATA.

[Names in *italics* those of extinct Groups].

Nervous centres enclosed in brain case and back bone; bilateral symmetry.

I. Mammalia,

Viviparous. Warm blooded; heart quadrilocular:

1. Archencephala.

Cerebral lobes concealing cerebellum and olfactory lobes. Corpus callosum.

Bimana. Thumb on anterior limbs only. (Man.)

2 Gyrencephala.

Lobes of cerebrum convoluted, cerebellum uncovered, olfactory lobes concealed. Corpus callosum.

A [*Digits with a nail.*]

a Quadrumana. Thumb on hind and fore limbs.

1. Catarrhina. (Gorilla, Chimpanzee, Macacus, *Pliopithecus.*)

2. Platyrrhina. (Cebus, *Protopithecus.*)

3. Strepsirrhina. (Aye Aye, Lemur)

b Carnivora.

[1]. Digitigrada. (Dog, Cat, Lion, Wolf, Fox, *Machairodus, Palæcyon.*)

[2]. Plantigrada. (Badger, Bear, *Hyænodon.*)

[3]. Pinnigrada. (Seal, Walrus.)

B [*Digits with a hoof.*]

c Artiodactyla. Even-toed on hind limbs.

[1]. Omnivora. Stomach simple. (Hippopotamus, Pig, Dicotyles, *Anoplotherium, Hyracotherium.*)

[2]. Ruminantia. Stomach compound. (Camel, Llama, Giraffe, *Irish Elk,* Deer, Cow, *Sivatherium.*)

d Perissodactyla. Odd toes on hind limbs.

[1]. Solidungula. Hoof single. (Horse, *Hipparion.*)

Multungula. Toes three or more. (Rhinoceros, Tapir, *Palæotherium.*)

e Proboscidia. Proboscis bearing mammals.

[1]. *Dinotherium.* Inferior incisors long, bent downwards. (*D. giganteum.*)

[2]. *Mastodon.* molars mammillated. Dentition, $\frac{1}{1}$ or $\frac{1}{0}$ or $\frac{0}{0} \cdot \frac{0}{0} \cdot \frac{2,\ 3}{2\ \ 3}$ or $\frac{0,\ 3}{0\ \ 3}$.

Pentalophodon. intermediate molars, five ridged. (*P. Sivalensis.*)

Tetralophodon. intermed. mol., four ridged. (*Tetr. Arvernensis.*)

Trilophodon. intermed. mol., three ridged. (*Tr. Ohioticus.*)

[3]. Elephas. molars ridged or plaited. Dentition, $\frac{1}{0} \cdot \frac{0}{0} \cdot \frac{2,\ 3}{2\ \ 3}$ or $\frac{0,\ 3}{0\ \ 3}$.

Stegodon. molars ridged, roof-shaped. Præmolars [?]. (*Steg. insignis.*)

Loxodon. molar lamellæ wedge-shaped. Præmolars, $\frac{2}{2}$ or $\frac{0}{0}$. (African Elephant, *L. planifrons.*)

Euelephas. molar lamellæ compressed. Præmolars, $\frac{0}{0}$. (Indian Elephant, *Mammoth.*)

f *Toxodontia.* (*Nesodon*, *Toxodon.*)

C [*Pectoral limbs as fins, posterior limbs wanting.*]

g Sirenia. Herbivorous Whales. (Manatee, *Stellerine*, *Zeuglodon*, Dugong.)

h Cetacea. True Whales. (Whale, Rorqual, Dolphin, Porpoise, *Cetotherium.*)

3. Lissencephala. Olfactory lobes and cerebellum uncovered, cerebrum smooth.

a Bruta. (Anteater, Armadillo, Sloth, *Megatherium*, *Glyptodon*, *Mylodon.*)

b Cheiroptera. Winged-handedMammals.

1. Frugivoridæ. (Pteropus.)
2. Insectivoridæ. (Flittermouse, or Bat.)

c Insectivora. (Shrewmouse, Hedgehog, *Galerix*, *Galeospalax*, Mole.)

d Rodentia. (Gnawers.)

1. Nonclaviculata. (Hare, Porcupine, *Cricetodon.*)
2. Claviculata. (Squirrel, Rat, Vole, Beaver, *Plesiarctomys.*)

4. Lyencephala.

Corpus callosum wanting, aplacental reproduction.

a Marsupialia. (Pouched Mammals.)

1. Rhizophaga. (Wombat.)
2. Poephaga. (Kangaroo, Kangaroo Rat, *Diprotodon.*)
3. Carpophaga. (Koala, Australian Opossum, Sugar Squirrel.)
4. Entomophaga. (Australian Cat, Virginian Opossum.)
5. ———. (*Thylacotherium*, *Phascolotherium.*)
6. Sarcophaga. (Tasmanian Wolf, Ursine Opossum, *Microlestes* [?] *Thylacoleo*).

b Monotremata.

Echidna, Platypus.

II. Aves or Birds,

Oviparous. Warm blooded; heart quadrilocular:

1. Raptores. (Hawk, Eagle, Vulture, *Lithornis*, Owl.)
2. Incessores.
    - *a* dentirostres. (Thrush, Wheatear.)
    - *b* conirostres. (Crow, Sparrow, Bunting.)
    - *c* scansores. (Woodpecker, Parrot, Wren, *Halcyornis* [?], Cuckoo.)
    - *d* tenuirostres. (Honeyeater, Humming-bird, Hoopoe, Bird of Paradise.)
    - *e* fissirostres. (Bee-eater, Roller, King fisher, Goat-sucker, Swallow.)
3. Rasores. (Pigeon, *Dodo* [?], Grouse, Partridge.)
4. Cursores. (Ostrich, Emeu, Apteryx, *Dinornis*, *Æpyornis* [?], *Palapteryx*.)
5. Grallatores.
    - *a* Pressirostres. (Bustard)
    - *b* Cultirostres. (Flamingo, Heron, Crane.)
    - *c* Longirostres. (Curlew, Snipe.)
    - *d* Macrodactyli. (Rail, Waterhen, Coot, Notornis.)
6. Natatores.
    - *a* Lamellirostres. (Swan, Duck, Merganser.)
    - *b* Totipalmides. (Pelican, Cormorant.)
    - *c* Mersatores. (Diver, Auk, Penguin.)
    - *d* Longipennidæ. (Gull, Seaswallow, Petrel.)

III. HÆMATOCRYMES.

A. III. Reptilia.

Oviparous or ovo-viviparous, cold blood, skin covered with scales or plates, breathe by lungs; heart trilocular. Scales epidermic, horny.

1. *Dinosauria*. (*Megalosaurus*, *Iguanodon*, *Hylæosaurus*.)
2. *Pterosauria*. (*Pterodactyle*.)
3. Testudinata. (Tortoise, Turtle.)
4. *Anomodontia*.
    - *a* *Dicynodontia*. (*Dicynodon*.)
    - *b* *Cryptodontia*. (*Oudenodon*.)
5. Loricata.
    - *a* *Procœli*. (Crocodile, Alligator, Gavial.)
    - *b* *Amphicœli*. (*Teleosaurus*.)
    - *c* *Prosthocœli*. (*Steneosaurus*, *Cetiosaurus*.)

6. *Thecodontia.* (*Thecodontosaurus, Palæosaurus.*)
7. Squamata.
   a Sauria. (Lizard, Iguana.)
   b Saurophidia. (Slowworm, Scinck.)
   c Ophidia. (Serpent, Snake, *Palæophis.*)
8. *Enaliosauria.*
   a Ichthyopterygia. (*Ichthyosaurus.*)
   b Sauropterygia. (*Plesiosaurus, Pliosaurus, Simosaurus.*)

B. III. BATRACHIA OR AMPHIBIA.

Oviparous, cold blood, generally naked skin, undergo metamorphosis for the most part, breathe by lungs or branchiæ, or both; heart trilocular.

1. Abranchia. no metamorphosis (?) or branchiæ. limbs four. (Menopoma, Amphiuma.)
2. Urodela. tail persistent. metamorphosis. limbs four. (Newt, Salamander, *Andrias.*)
3. Anoura. tail deciduous. metamorphosis. limbs four. (Frog, Toad, *Palæobatrachus.*)
4. Apoda. body anguiform. metamorphosis. limbs none. (Cecilia.)
5. Amphipneusta. gills persistent. metamorphosis. limbs four or two. (Proteus, Siren, Menobranchus.)
6. Lepidota. body scaly, fish-shaped. limbs four, rod-like. (Lepidosiren, Protopterus.)
7. *Ganocephala.* head with ganoid bony plates. limbs, four natatory. (*Archægosaurus.*)
8. *Labyrinthodontia.* (*Labyrinthodon.*)

C. III. PISCES OR FISH.

Cold blood, oviparous, breathe by branchiæ; heart bilocular. Scales developed as distinct organs in substance of skin.

1. Plagiostomi. scales placoid. skeleton cartilaginous or osteoid. gills fixed. gill openings five or more.
   a Squali. (Shark, Cestracion, *Ctenodus.*)
   b Raiæ. (Torpedo, Sawfish, *Cyclarthrus.*)
2. Holocephali. scales placoid. skeleton cartilaginous. gills fixed by margin. gill opening one. (Chimæra, *Elasmodus.*)
3. Ganoidea. scales ganoid. skeleton osseous, cartilaginous or osteoid. (Lepidosteus, Polypterus, Sturgeon, *Chondrosteus, Coccosteus, Cephalaspis.*)

4. Lophobranchii. scales ganoid. skeleton osteoid. gills tufted. (Pipe-fish, Sea-horse, *Calamostoma.*)
5. Plectognathi. scales ganoid. skeleton osteoid. maxillary and premaxillary bones soldered. (File-fish, Globe-fish, Sun-fish, *Acanthoderma, Blochius.*)
6. Acanthopteri. scales ctenoid, rarely cycloid. skeleton osteoid or osseous. (Thynnus.) anterior rays of fins inflexible. (Perch, *Holopteryx*, Gurnard, Mackerel, *Callipteryx.*)
7. Anacanthini. scales ctenoid or cycloid. skeleton osteoid. fin rays flexible.
   a Thoracici. (Ophidium, Cod.)
   b Anisomeri. (Plaice.)
   c Colacides. (Remora.)
8. Pharyngognathi. scales ctenoid or cycloid. skeleton osteoid. Inferior pharyngeal bones soldered.
   a Acanthopterygii. (Saury-pike.)
   b Malocopterygii. (*Platylemus*, Flying-fish, Wrasse.)
9. Malacopteri. scales cycloid or ganoid. skeleton osseous or osteoid. gills free operculate. fin rays for the most part soft.
   a Helmicthyi. (Anglesey Morris.)
   b Apodes. (Eel.)
   c Abdominales. (Herring, Salmon, Pike, *Holosteus.*)
10. Cyclostomata. gills fixed; bursiform; inoperculate. skeleton cartilaginous. (Myxine, Lamprey.)
11. Leptocardia. gills pharyngeal; free; inoperculate. Skeleton cartilaginous. heart absent. (Lancelet.)

Agassiz's Classification.

1. Ganoideans. (Lepidosteus, *Coccosteus, Pterichthys, Cephalaspis*, Sturgeon.)
2. Placoideans. (Sharks, *Spinax*, *Sclerodus*, Rays.)
3. Ctenoideans. (Perch, *Beryx.*)
4. Cycloideans. (Carp, *Rhonchus*, Herring, Salmon.)

Some place the Protopterus (*vide* Batrachia) among the fish as the type of a family, Protopteri. They also unite 10 and 11 under the name of Dermopteri.

MOLLUSCA, OR HETEROGANGLIATA.

Nervous centres scattered, unsymmetrical, bodies soft.

I. Cephalopoda.

Bodies symmetrical, head distinct, arms around head, respiration by branchiæ in special cavity.

1. Dibranchiata.
   branchiæ 2.
   a octopoda. (Argonaut, Poulpe.)
   b decapoda. (Squid, *Belemnite*, Spirula.)
2. Tetrabranchiata.
   branchiæ 4. (Nautilus, *Orthoceras*, *Bacculite*, *Ammonite*.)

II. Cephalophora.

Bodies unsymmetrical, head distinct, respiration various, some species undergoing metamorphosis.

1. Gasteropoda.
   foot a broad fleshy disk.
   a prosobranchiata. branchial respiration; special cavity. (Chiton, Whelk, Ianthina, Limpet, *Euomphalus*, Periwinkle.)
   b pulmonifera. pulmonary cavity. (Snail, Slug.)
   c opisthobranchiata. branchial respiration. (Doris, Aplysia, Bulla.)
2. Heteropoda.
   foot a vertical plate, (*Bellerophon*, Atlantas, Carinaria, Firola.)
3. Pteropoda.
   fins each side of head, (Clio borealis, Hyalea, *Pterotheca*.)

III. Acephala or Conchifera Lamellibranchiata.

Body unsymmetrical, lamellar branchiæ between folds of mantle, valves of shell lateral.

1. Asiphonophora.
   Mantle lobes either free or united at back only. (Oyster, Mussel, Arca, Unio.)
2. Siphonophora.
   Animals furnished with retractile siphons. (Chama, Cockle, Teredo, Cyclas, Razor-shell, Mya, Pholas, *Hippurites*.)

IV. Molluscoidea.

Bodies unsymmetrical, nervous ganglions.

1. Brachiopoda or Palliobranchiata.
   Respiration by edges of mantle, arms attached to each side of mouth, shells dorsal and ventral.

a Lingulidæ.

Peduncle passing between valves. (Lingula, *Obolus*).

b Terebratulidæ.

Peduncle passing through ventral valve. (Terebratula, *Spirifer, Pentamerus, Orthis, Productus.*)

c Craniadæ.

(Crania, Discina.)

2. Tunicata or Ascidioida.

a Biphoridæ, mantle coriaceous.

Branchiæ band-like, circulation flux and reflux. (Biphora.)

b Ascididæ.

Branchiæ netted. (Botryllus, Clavellina, Ascidia, Pyrosoma.)

3. Polyzoa or Bryozoa.

Ciliated tentacles around mouth. Animals in groups, reproduction oviparous or gemmiparous.

a Lophopoda.

Tentacles on arms each side of mouth. (Plumatella.)

b Infundibulata.

Tentacles in circle around mouth. (Flustra, Bowerbankia, Crisis.)

ARTICULATA, OR ANNULATA.

Nervous centres in pairs symmetrically arranged in parallel lines.

I. Insecta.

Legs six, head, thorax, and abdomen distinct, respiration tracheal, metamorphosis.

1. Coleoptera. Wings, four, two, or none, upper wings generally coriaceous, mouth with jaws. (Beetle, *Carabites,* Stylops.)
2. Neuroptera. Wings, four or none, mouth with jaws, wings with interlacing venules. (Earwig, Locust, Cricket, Dragon-fly, White Ant, Lepisma, *Dictyophlebia.*)
3. Lepidoptera. Wings four or none, scaly. Mouth, suctorial. (Butterfly, Moth.)
4. Hymenoptera. Wings four or none. Venules free. Mouth, suctorial. (Bee, Sawfly, Ichneumon, Ant, Wasp, *Cephites, Attopsis.*)
5. Diptera. Wings, two or none. Under wings as halteres. Mouth, suctorial. (Flea, Housefly, Mosquito.)

6. Hemiptera. Wings, four or none. Coriaceous at their base. Mouth, suctorial.
   (Bug, Cicada, Aphis, Pediculus, *Blattina.*)

II. Crustacea.

Body articulated, cephalo thorax and abdomen, articulated limbs, dermal or branchial respiration, undergo metamorphosis.

1. Podophthalmia. Eyes on footstalks, thoracic rings concealed beneath carapace.
   a Eubranchiata or decapoda.
   legs ten, branchiæ in special cavity.
   1. brachyura. (Crab, *Xanthopsis.*)
   2. anomoura. (Hermit Crab.)
   3. macrura. (Lobster.)
   b Anomobranchiata.
   branchiæ various.
   1. stomapoda. Feet around mouth. (Squill.)
   2. schizopoda. Feet numerous, cleft. (Mysis.)
   3. aploopoda. Feet simple, numerous. (Leucifer.)
2. Choristopoda or tetradecapoda. Eyes sessile, thoracic rings exposed.
   thoracic feet fourteen; branchial vesicles.
   a. Amphipoda.
   branchial vesicles thoracic, thoracic feet 8 anterior, 6 posterior. (Gammarus, Cyamus, *Prosoponiscus.*)
   b. Anisopoda.
   branchial vesicles abdominal, thoracic feet 8 anterior, 6 posterior. (Tanais, Arcturus, Serolis.)
   c. Isopoda.
   branchial vesicles abdominal, thoracic feet 6 anterior, 8 posterior. (Wood-louse, Ligia, *Archægoniscus.*)
3. *Trilobites.* (*Calymene, Paradoxides, Trinucleus, Asaphus, Agnostus.*)
4. Entomostraca.
   a. Gnathostomata. movable jaws.
   1. phyllopoda.
   segments numerous, with foliaceous appendages beneath. (Apus, Limnadia, *Dithyrocaris.*)
   2. lophyropoda.
   feet few, posterior part of body, furnished with hairy appendages. (Cyclops, Daphnia, Cypris, *Caprella.*)
   b. Cormostomata.
   mouth with retractile sucker. (Caligus, Lernæa.)

c. Merostomata.

basal joints of legs, as jaws. (Limulus, *Bellinurus.*)

d [?] *Eurypteridæ.* (*Eurypterus, Pterygotus.*)

5. Cirripedia.

a thoracica. (Barnacles, Lepas, Verruca.)

b abdominalia. (Cryptophialus.)

c apoda. (Proteolepas.)

III. Arachnida.

Eight articulated imperfect thoracic limbs, cephalo thorax, and abdomen, respiration various, metamorphosis.

1. Pulmonaria. pulmonary cavity. Abdomen only articulated.

a Scorpionidæ. cephalo thorax and abdomen indistinctly separated. cheliceres forficulate. (Scorpion, Androctonus. *Sc. cyclopthalmus.*)

b Phrynidæ. abdomen distinct. cheliceres. nailed. (Phrynus.)

2. Dipneusta. Respiration tracheal and pulmonic. Abdomen and cephalo thorax distinct, unarticulated. (Mygale, House Spider.)

3. Trachearia. Respiration tracheal. Cephalothorax unarticulated or biarticulated.

a Solpugidæ. Abdomen articulated, distinct. palpi simple. (Galeodes.)

b Pseudoscorpii. Abdomen articulated, semifused. palpi forficulate. (Chelifer, Obisium, *Microlatis.*)

c Opilionidæ. Abdomen articulated, semifused. palpi simple. (Phalangium.)

d Acarinæ. Abdomen unarticulated, fused. palpi simple. (Sarcoptes, Acarus, Trombidium.)

4. Apneusta. Cephalo thorax multiarticulate. No special respiratory organs.

a. Pycnogonidæ. Abdomen rudimentary. (Nymphon, Pycnogonum.)

b Tardigrada. Abdomen none. Legs rudimentary. (Linguatula [?], Milnesium.)

IV. Myriapoda.

Body articulated, joints all distinct, numerous articulated limbs, undergo partial metamorphosis, respiration tracheal.

1. Chilopoda:

(Centipede, Geophilus, Cermatra, Lithobius.)

2. Chilognatha.

(Glomeris, Julus, Polydesmus.

RADIATA.

Nervous filaments or threads

I. ROTATORIA.

mouths surrounded by ciliated lobes.

a. Sessilia (Floscularia).

b. Natantia (Polytrochus).

II. ANNELLIDA.

Body ringed, no limbs. Metamorphosis.

1. Dorsibranchia or Errantia.
   branchiæ attached to each segment.
   (Eunice, Nereis, Seamouse, Lugworm.)
2. Tubicolæ.
   branchiæ to anterior segment.
   (Terebella, Serpula, Sabella.)
3. Scolecidea.
   pulmonic (?) cavity.
   double rows of bristles along side.
   (Earthworm, Nais.)
4. Suctoria.
   bodies with sucking discs. Pulmonic (?) cavity.
   (Leech, Branchiobdella.)

III. NEMATELMIA.

Body elongated, cylindrical.

1. Nematoidea. (Ascaris, Guineaworm.)
2. Gordiaceæ. (Gordius.)
3. Acanthocephalaceæ. (Echinorhynchus.)

IV. PLATYELMIA.

Body flattened, no segmentation. Animal often compound.

1. Planaridea.
   free. Ciliæ. (Turbellaria, Borlasia (?) Planaria.)
2. Trematodea.
   parasitic, body short, elliptical.
   (Distoma, Tristoma, Polystoma.)
3. Cestoidea.
   parasitic, generally compound, bodies flattened.
   (Tapeworm. Bothriocephalus.)

V. Echinodermata.

1. Sipunculoidea. (Sipunculus.)
2. Holothuriadea. (Sea cucumber, Nigger.)
3. Echinoidea.

   a Spatangidæ. (*Holaster*, Spatangus, *Ananchytes.*)
   b Clypeastridæ. (Pea Urchin, *Clypeus.*)
   c Cidaridæ. (Egg Urchin, Piper.)

4. *Perischœchinoidea.* (*Palœchinus.*)
5. Asteroidea. (Sunstar, *Palœaster.*)
6. Ophiurioidea. (Sandstar, Brittlestar.)
7. Crinoidea.

   a Comatulidæ. (Featherstar, *Pterocoma.*)
   b *Cupressocrinidœ.* (*Cupressocrinus.*)
   c *Polycrinidœ.* (*Eucalyptocrinus.*)
   d *Haplocrinidœ.* (*Haplocrinus.*)
   e *Anthocrinidœ.* (*Crotalocrinus.*)
   f *Cyathocrinidœ.* (*Cyathocrinus, Actinocrinus, Platycrinus, Carpocrinus.*)
   g Pycnocrinidæ. (*Eugeniocrinus, Encrinus, Apiocrinus,* Pentacrinus.)

8. *Blastoidea.* (*Pentremites, Isocrinus.*)
9. *Cystidea.* (*Caryocrinus, Cystis.*)

Some systematists place Sipunculoidea among the Annellida.

Huxley unites Articulata and Radiata as Annulata, dividing them into Articulata corresponding to Articulata, and Annulosa corresponding to Radiata.

PROTOZOA OR ACRITA.

No nervous centres or filaments as yet detected.

I. Polypifera, or Cœlenterata.

1. Actinozoa. digestive sac suspended in general cavity.
   a Asteroida, tentacles eightfold. (Alcyonium, Red coral, Music coral.)
   b *Rugosa* (*Cyathophyllum.*)
   c Helianthoida, tentacles five or sixfold. (Sea anemones.)
   d Ctenophora. (Beroe, Cestum Veneris.)

2. Hydrozoa. No general cavity.

a Lucernaroida. Polype single, with a swimming organ.

[1]. Lucernaridæ. Natatorial organ, with adherent base. (Lucernaria.)

[2]. Medusidæ. (Æginopsis.)

b Siphonophora. Polypes several in cœnosarc, with natatorial organs.

[1]. Physophoridæ. Cœnosarc dilated into a float. (Portuguese man-of-war.)

[2]. Calycophoridæ. (Diphys, Cymba.)

c Hydroida.

[1]. Sertularidæ. Polyps with cœnosarc in cells, fixed. (Sertularia, *Oldhamia.*)

[2]. Tubularidæ. Polyps, naked, fixed. (Tubularia.)

[3]. Hydridæ. Polype single naked, free. (Hydra.)

II. Oozoa or Protozoa.

1. Infusoria. (Vorticella, Euglena.)
2. Porifera. (Sponges.)
3. Rhizopoda. (*Nummulites,* Foraminifera, Amæba.)

Huxley places Oozoa as a subkingdom.

III. DISTRIBUTION,

INCLUDING PALÆONTOLOGICAL ZOOLOGY.

Types unequally distributed in both space and time. Diversities among Animals as regards mode and manner of living. Fauna—Group of Types inhabiting a district. Marine Faunas. River and Lake Faunas. Land Faunas; subdivisions of latter, Faunas of circumstance. Differences of Faunas not due merely to physical differences of districts nor to their present geographic position. Laws of Animal existence. Most important physical agents which modify Faunas, Light, Heat, and Moisture. *Range of existence,* or degree of variation of these compatible with existence of Species. *Limit of existence,* or extremes of range outside of which Species must absolutely perish. *Standard of existence,* or range within which Species live and *flourish.* These not necessarily uniform for each of the Species found in any particular district; so that a Species belonging to any particular Fauna may perish whilst others will still survive. Faunas of

area. Limitation of Types to certain districts, and their probable origin there. Centres of creation. Transmission of Species from one centre to another, generally by continuity of surface. Capital. Foundation of colonies. Colonies may survive original capital, and even recolonize it. Modes in which Faunas vary. Creation of Species. Spread of Species from other centres, either by contiguity or by accident. Destruction of Species. Cases of *total* extinction of Types since the appearance of man. Cases of *partial* extinction of Types, *i.e.*, their disappearance from special areas. *Hence Species may become extinct either entirely or from some special area.* Causes of extinction :—1st. Alteration in physical characters of district dependent on geologic changes. 2nd. Introduction of hostile Species. Geographic Faunas. Representative Faunas. Identical Faunas. Reintroduction of partially extinct Species very limited in its extent. No Species which has once become entirely extinct has ever reappeared.

Generic Types have been reintroduced.

Extinct Types. Fossils or Organic remains; their nature. Animal traces, remains of Organs, or traces of remains of Organs. Absolute identity of many of these with Organs of living Types, or traces of living Types. Absolute distinctness of many from any known specific or generic Type, yet perfect holotypical agreement of all with existent Types. Many living Types not known Fossil. Theories proposed to account for these Phenomena. The Prochronic theory; its difficulties and apparent absurdity. The Progressive, Development, and Degradation theories; their falsehood and absurdity. The Selective theory; its extreme improbability.

Nature of Parts preserved. Mode of Preservation. Parts preserved. Skeleton and hard parts either themselves or at least casts of their several parts. Impressions of soft parts often preserved. Evidence that Types lived under same conditions as kindred Types of present day. Peculiar Types lived during different ages of the world's history, which afford us means of marking geological periods.

General Conclusions.

1. Every Species has made its appearance in a limited area, and from thence spread to neighbouring districts, either by continuity or accident, often hereby causing the foundation of a colony, which may outlive, and in rare cases, recolonize the capital.

2. To every Species of a Fauna there is an independent ***standard and limit of existence.***

3. Species may become either *totally* or *partially* extinct; in the former case the Species not reappearing on the earth.

4. Fossil Remains agree with recent Types in arrangement of hard parts, and also in the form of those soft parts whose impressions have been preserved. Hence we are justified in believing that the extinct animal types were arranged on the same general plan as living ones.

5. That fossil animal traces are found identical with those formed by living types, showing that the life-history of extinct types was similar to that of existing types, and carried on under similar conditions.

6. That limited centres of creation are traceable among Fossils, peculiar generic and family Types being sometimes limited to same areas as at present.

7. The limit of existence of Species sprung from the same centres not being necessarily identical, Species of one geologic period may be found coexistent with those of a much later period, and hence that there is no necessary limit to the duration of a Species through time.

8. That Types which compose Faunas were not necessarily all of same age, nor from same origin.

9. That the Types which first appeared, whilst agreeing with existing Archetypes in general relations, differ from existing subtypes in degree of specialization of organs.

Examination and application of these laws. Faunas of northern and southern regions compared and contrasted.

Special Examination of Fauna of British Isles.

IV. ECONOMIC ZOOLOGY.

I. Animal Substances used in Arts and Manufactures:

Oils and Fats, and allied substances; Mammalian Oils and Fats: the sources whence derived and modes of procuring. Fish Oils: modes of production. Wax: the Insects which furnish it.

Skin and tegumentary appendages; Skins, Furs, Hides, Shagreen, Wools, Hair: sources whence derived. Bristles, Whalebone, Horn, Tortoiseshell, Cameos: Pearly manufactures.

Skeleton and allied substances: Bone, Ivory, Sponge, Coral.

Animal Dyes mechanically prepared; Dye Insects.

Miscellaneous substances: Glue, Isinglass, Silk.

Alimentary substances.

II. Animals noxious to Man:

Insects, &c., hurtful to the Agriculturist; Insects, &c., hurtful to the Manufacturer.

III. Animals cultivated by Man; Review of domesticated races; other domesticated Animals.

IV. Animals of capture:

Animals hunted for their Skins and Furs, &c.

Fisheries: Home Fisheries, Foreign Fisheries: description and enumeration of modes of capture, and sources whence several baits employed are derived.

Class books recommended: Dallas' "Natural History of the Animal Kingdom;" Green's "Manual of Protozoa."

Additional for Honors: Carpenter's "Principles of Comparative Physiology;" Siebold's "History of Invertebrata," translated by Burnett; Rymer Jones' "Animal Kingdom;" Owen's "Classification and Distribution of Mammalia;" Owen's "Palæontology."

N.B.—The important parts of the books recommended for Honors, will be pointed out during the courses.

BOTANY.

Structural and Physiological.

Professor.—W. H. Harvey, M.D.

Introduction.—The elementary organs of plants. Cellular and Vascular Tissues. Cellular Tissue, its general structure and varieties. Isolated Cells. Parenchyma and Prosenchyma. Fibrocellular Tissue; dotted; and pitted tissue or Bothrenchyma. Woody Tissue or Pleurenchyma. Glandular Woody Tissue. Vascular Tissue, consisting of spiral vessels and ducts, its structure and usual position. Annulated, reticulated, and scalariform ducts. Laticiferous Tissue. Intercellular system and air-vessels; secreting cells and internal glands. Epidermal system; epidermis, stomates, hairs, bristles, prickles, stings, scales. Contents of the Tissues; sap, crude and elaborate; starch, chlorophyll, &c. Raphides. Proper secretions.

General Morphology of the Plant. The Individual. Its simplest form; plants of a single cell;—Protococcus, Oscillatoria, Vaucheria. Plants formed of a string of cells;—Nostoc, Conferva, &c. Spores of Cryptogamia and early stage of Mosses and Ferns. Plants consisting of a flat cellular membrane;—Ulva, &c. First appearance of a Stem or Axis, and of Foliage. Frondose Plants, in which Stem and Leaves are confounded. Crustaceous and Frondose Lichens. Evolution of Stem and Leaf in Algæ. In Hepaticæ and Mosses. Ferns. Cormophytes and Thallophytes. Root, Stem and Leaf of Cotyledonous Plants, exist ready formed in the

embryo of the seed. Ordinary development of a Cotyledonous embryo. Instances, in Cotyledonous Plants, of arrested development of one or more of the organs of vegetation.

The Root or descending Axis. Primary and secondary Roots. Primary Roots, their general characteristics, mode of growth and office. Secondary Roots. Roots of the Cryptogamia. Aerial Roots, of Ivy, Banyan, Pandanus, Mangrove, Airplants or Epiphytes, &c. Parasitic Roots. Green or Leafy Parasites, and Coloured or Scaly Parasites. Misseltoe and Loranth. Cuscuta. Rafflesia, Cytinus, Orobanche, &c.

The Stem or ascending Axis, antagonistic to the Root. Its growth and external modifications. Essential characters. Nodes and internodes. Mode of development. Normal position of leaf-buds. Development of branches, and causes of irregular branching. Dormant, adventitious and accessory buds. Stems distinguished into excurrent and diliquescent; examples. Definite and indefinite growth. Special modifications of stem; culm; caudex; decumbent, ascending, prostrate, creeping, climbing, and twining stems; stolones and suckers. Spines and thorns. Underground stems; rhizome, tuber, corm, bulb, &c. The internal structure of stems. Longitudinal and horizontal systems. Acrogenous, Endogenous and Exogenous stems. Structure of the Endogenous stem. Of the Exogenous. Deposition of wood plates, and distinction of a central pith, medullary sheath, wood-circle, medullary rays, and bark. Structure and varieties of these several parts. The bark separable into four layers of cells; the Epidermis or outer skin; the Epiphlæum or corky layer; the Mesophlæum or green layer; and the Endophlæum, fibrous layer or Liber. The Cambium. Sapwood or alburnum, and heartwood or duramen. Annual circles of growth.

Arrangement and development of leaves. Phyllotaxis or the distribution of leaves. Opposite, alternate, verticillate, and fascicled leaves. Radical, cauline, rameal and floral leaves. Parts of a leaf; petiole, lamina, base, apex. Sessile, perfoliate and peltate leaves. Stipules. Development of a young leaf. Terms used to describe the principal forms of leaves. Laciniated and multifid leaves. Compound leaves. Defective leaves. Phyllodia or leaf-like petioles. Phyllocladia or leaf-like branches. Pitchers. Sensitive leaves of Dionæa, &c. Anatomy and physiological action of the leaf. Its woody and cellular systems. Arrangement of the cells. Epidermis. Stomates or breathing pores. Hairs. Duration of leaves, and causes of their decay and fall.

Production of flower buds. Their arrangement on the

stem or inflorescence. Peduncle and pedicel. Bractea. Involucre. Definite and indefinite inflorescence. Principal modification of the indefinite inflorescence; raceme, corymb, umbel, spike, spadix, catkin, head or capitulum. Ordinary capitula of compound flowers (*Compositæ*), the involucre, receptacle, and paleæ; the ray, and disc florets. Anomalous capitulum of the Fig. Compound racemes; panicle, thyrsus. —Definite inflorescence: the Cyme, simple and compound; fascicle, glomerule. Scorpioid cyme of Boragineæ. False whorls in Labiatæ. Mixed inflorescences. Evolution of heat in flowers. Exhaustion and season of rest in plants.

The Floral Organs. Theoretical structure and morphology of a Flower. Flower-bud and leaf-bud of similar origin. Same laws govern arrangement of parts of a flower and the distribution of leaves on a branch: a flower is therefore a shortened branch. All its parts, however dissimilar, referable to a common archetype—the Leaf. This may be illustrated by instances of normal or abnormal passage of one floral organ into another, and of leaves and bracteæ into floral organs; or by the occasional abnormal return of floral parts into ordinary leaves.

Floral Envelopes—The Bracteæ, Calyx, and Corolla, differ from each other merely in their relative position; their purpose is similar, and any one may supply the place of another. Bracteæ, Involucres, and Involucels, serve as floral envelopes in Grasses, and as pistils in Pine-cones. Perianth: Calyx and Corolla. Symmetrical and Nonsymmetrical Flowers. Principal causes of want of symmetry—1st, Augmentation, or multiplication of the floral whorls; 2nd, Chorisis or Deduplication, an increase by the lateral or facial splitting or branching of individual parts; 3rd, Coalescence, or union of the pieces of the same circle—thus are formed monophyllous (gamosepalous) calyces, and monopetalous (gamopetalous) corollas; 4th, Adnation, or coherence of the pieces of different circles—as, of the bases of the calyx and corolla with the pistil, of the calyx with the corolla, of the corolla with the stamens, of the stamens with the style, &c.; 5th, Irregularity, or unequal development and unequal union, as the Pea-flower (Papilionaceous corolla), Lobelia, Violet, Orchis, &c.; 6th, Suppression or Abortion, as the depauperation of corolla and substitution of a coloured calyx (Fuchsia, Daphne, &c.); depauperation of calyx, as in Umbelliferæ and Compositæ; disappearance of both calyx and corolla, as in Euphorbia, &c.

Andrœcium or Staminal Circle. Stamens, filament, anther, connective, pollen. Hypogynous, perigynous, epigynous, and gynandrous stamens. Monadelphous, diadelphous, &c. Te-

tradynamous. Syngeneseous. Exserted, included, declined. Definite and indefinite. Innate, adnate, and versatile anthers; their dehiscence either introrse or extrorse, valvular, or porous. Structure of anther case. Development of the pollen and its various forms, and structure.

Gynœcium or Pistil: the centre of the flower and end of the axis of growth. Pistils are monogynous, digynous, trigynous, &c., or polygynous, as they consist of one, two, three, or more, *carpels* or fruit leaves. Apocarpous and syncarpous pistils. Parts of a pistil: the ovary, style, stigma. Unilocular, bilocular, trilocular, &c., ovaries; dissepiments, normal and spurious. Placentæ, parietal and axial. Free central placentæ. Ovules; their number and position. Development of the ovule, and ultimate structure. Primine, secundine, foramen, chalaza. Atropous, campylotropous, and anatropous ovules. Fertilization of the embryo.

Formation and structure of Fruit. Pericarp; its varieties. Various anomalous compound fruits. Changes of structure after fertilization. Epicarp and Endocarp. Sarcocarp. Dehiscence of fruits; septicidal, loculicidal, and septifragal, valvular and porous. Follicle, Legume, Lomentum, Drupe, Achene, Cremocarp, Caryopsis, Utricle, Nut, Samara, Berry, Pome, Pepo, Capsule, Pyxidium, Siliqua and Silicula, &c.

The Seed; its testa or outer coat, and tegmen or inner coat, and nucleus. Varieties of Testa. Funiculus, hilum, chalaza, micropile. Arillus. The Nucleus; albumen and embryo. Cotyledons, radicle and plumule. Monocotyledonous, dicotyledonous, and polycotyledonous embryos. Accumbent and incumbent radicles. Germination of seeds.

Development of the fruit in cryptogamia or flowerless plants. Spores and Antheridia.

Physiology of Vegetation. Food of plants; its imbibiture and assimilation. Elementary organic and inorganic constituents. Influence of light, heat, air, &c., on growth. Assimilation and decay of plants. Products of plant-respiration and effect of vegetation on the atmosphere.

Geographical Distribution of Plants. Effect of climate on vegetation, and of vegetation on climate. Cultivated plants. Weeds of cultivation, &c.—Remarks on Species, Genera, and Orders, introductory to Systematic Botany.

Systematic.

Artificial or sexual system of Linnæus. Natural Systems, of Ray, Decandolle, Jussieu. The uses of systems in general, and the comparative value of natural and artificial arrangements.

OUTLINES OF BOTANICAL SYSTEM.

Sub-kingdom I. PHANEROGAMIA.—Plants propagated by *seeds*, containing an *embryo* or miniature plantlet.

Class I. DICOTYLEDONES or EXOGENÆ.—*Embryo* di-poly-cotyledonous. *Stem* consisting of concentric layers of wood, surrounding a central pith, and enclosed within a separable bark. *Leaves* usually netted-veined. *Flowers* commonly 4-5-merous.

Sub-class I. ANGIOSPERMEÆ.—*Ovules* contained in an ovary; fertilized through the intervention of a stigma. To this Sub-class belong most of the Orders of Exogens: for convenience sake it is generally subdivided into four groups of Orders, as follows:—

Group 1. THALAMIFLORÆ.—*Calyx* and *corolla* generally present. *Petals* and stamens hypogynous. *Ovary* free.

Group 2. CALYCIFLORÆ.—*Calyx* and *corolla* generally present. *Petals* (or monopetalous corolla) either perigynous or epigynous. *Stamens* perigynous, epigynous, or epipetalous.

Group 3. COROLLIFLORÆ.—*Calyx* and *corolla* both present. *Corolla* monopetalous, nearly hypogynous. *Stamens* epipetalous. *Ovary* free or nearly so.

Group 4. MONOCHLAMYDEÆ.—*Perianth* single, or imperfect, or none. *Stamens* variously inserted.

Sub-class II. GYMNOSPERMEÆ.—*Ovules* naked (not contained in an ovary), fertilized by the direct action of the pollen on their foramen. (The Orders *Coniferæ*, *Cycadeæ*, and *Gnetaceæ*, form this Sub-class.)

Class II. MONOCOTYLEDONES or ENDOGENÆ.—*Embryo* monocotyledonous. *Stem* consisting of bundles of woody and vascular tissue, separately imbedded in cellular tissue, and encased in a firmly adherent outer rind; no concentric wood-layers, and no separable bark. *Leaves* usually straight-veined. *Flowers* commonly tri-merous.

Group 1. PETALOIDEÆ.—*Flowers* usually with a more or less perfect perianth; not surrounded by scarious bracts.

Group 2. Glumaceæ.—*Flowers* without a proper perianth, but surrounded by *glumes* or scarious bracts. (To this group belong the Orders *Cyperaceæ* and *Gramineæ*.)

Sub-kingdom II. CRYPTOGAMIA.—Plants propagated by *spores*, or cellular reproductive bodies which do not contain an embryo or miniature plantlet.

Class I. ACROGENS.—Mostly herbaceous, and provided with distinct, often stoloniferous, foliaceous appendages. Spores, for the most part, producing a prothallus, or if not, complicated fruit by means of the impregnation of an embryonic cell. Spermatozoids spiral.

Sub-class I. FILICALES, Berk.—"Spores producing a prothallus by germination, or by cell-division homologous with germination. *Archegonia* formed in the prothallus, producing, after impregnation, a distinct sporiferous plant."—*Berk.*

Order 1. Filices, Juss.—*Fronds* circinate when young; the fertile bearing on their under surface tufts (*sori*) of sub-globose sporangia, mostly girt with a distinct, often elastic ring (*annulus*), naked, or covered with a membrane (*indusium*), which generally springs from a vein of the frond. *Rhizome* creeping or erect; sometimes trunk-like. (This Order, containing the true ferns, is divided into eighteen families or sub-orders, characterised by the presence, absence, or condition of the ring, or of the indusium. *See Berk. Introd. to Crypt. Bot. p.* 522.)

Order 2. Ophioglossaceæ, Lindl.—*Fronds* straight in vernation; fertile fronds reduced to a linear process, the edge of which produces a single row of connate, bivalve sporangia. *Berk. l. c. p.* 547. (Consists of the genera *Ophioglossum, Botrychium*, and *Helminthostachys*.)

Order 3. Equisetaceæ.—*Stem* articulated, hollow, whorled with branches; each joint of the stem and branches surrounded by a toothed sheath (formed of minute, confluent, whorled leaves). *Sporangia* affixed to the

under surface of the peltate scales of terminal cones. *Spores* subtended by two spiral fillets. *Berk. l. c. p.* 549. (The genus *Equisetum* constitutes this Order.)

Order 4. Marsileaceæ.—*Vernation* straight or circinate. *Receptacles* (involucres?) more or less radical, uni- or multilocular. *Sporangia* monosporous, in the same receptacle with the antheridia or in different receptacles. *Berk. l. c. p.* 552. (Consists of a few water plants, forming the genera *Marsilea, Pilularia, Salvinia,* and *Azolla.*)

Order 5. Lycopodiaceæ.—*Sporangia* bi-trivalvular, unilocular, rarely multilocular, axillary, containing spherico-tetrahedral spores. *Antheridia* closely resembling the sporangia, filled with minute, dust-like bodies, shaped like the spores, and at length producing spermatozoids. *Leaves* simple, straight in vernation, alternate, nerved; rarely absent. *Stem* continuous, branched. *Berk. l. c. p.* 556. (Consists of the genera *Lycopodium, Selaginella, Phytoglossum, Tmesipteris, Psilotum,* and *Isoetes.*

Sub-class II. MUSCALES, Lindl.—"Spores numerous (never solitary), produced within variously formed capsules (*thecæ*), giving rise, after germination, to an annual or perennial frond or leafy plant. *Archegonia* formed on the perfect plant, and producing, after impregnation, sporiferous fruit."—*Berk. l. c. p.* 430.

Order 1. Musci, Juss., or Bryaceæ, Lindl.—*Sporangia* valveless (or very rarely valvate, with the tips of the valves free or adherent), opening mostly by a horizontal fissure, the mouth of which is naked or fringed with teeth. *Elaters* none. *Calyptra* parting at the base and carried up by the peduncle, rarely ruptured in the midst. *Leaves* simple, alternate. *Antheridia* on the same or on different plants form the Archegonia. (To this belong all the true mosses, including *Andræa* and *Sphagnum.* They are grouped by Berkeley into five sub-orders, and these are again subdivided into forty-three families.)

Order 2. Jungermanniaceæ, Lindl.—*Sporangia* solitary, splitting into four equal valves. *Spores* mixed with elaters. *Berk. l. c. p.* 444. (This large Order is subdivided into fifteen families or sub-orders, see *Berk. l. c. p.* 448.)

Order 3. Marchantiaceæ, Corda.—*Sporangia* valvate or bursting irregularly, mostly symmetrically placed on the under surface of pedunculated, peltate receptacles; rarely solitary and sessile. *Spores* mixed with elaters. *Antheridia* lodged in proper, sessile or pedunculate, peltate or discoid receptacles. *Cuticle* areolate, porous. *Berk. l. c. p.* 436. (Divided into three sub-orders, see *Berk. l. c. p.* 438.)

Order 4. Ricciaceæ, Lindl.—*Sporangia* valveless, sunk in the substance of the frond or raised above its surface; surrounded by, or adnate with the calyptra, with or without additional envelopes, bursting irregularly, and producing spores without elaters. *Berk. l. c. p.* 438.

Sub-class III. CHARACEALES, Berk.—*Fronds* consisting of confervoid, articulate threads or strings of cells. Fruit monoecious or dioecious. *Female:* spores solitary, coated with spirally-arranged cells, at once reproducing the plant. *Male:* brick-red globules, consisting of eight spherically-triangular discs, from the centre of each of which a centripetal column springs perpendicularly, bearing toward the apex articulated threads, each articulation of which produces a spiral spermatozoid. *Berk. l. c. p.* 426. (The Order *Characeæ*, consisting wholly of aquatic plants, in structure of frond resembling *Confervæ*, constitutes this sub-class.)

Class II. THALLOGENS.—Seldom herbaceous or provided with foliaceous appendages; foliaceous appendages, if present, destitute of stomata. Spores rarely producing a prothallus; and if so, giving rise to a second order of spores, germinating at definite points. Spermatozoids not spiral. *Berk. l. c. p.* 69.

Sub-class I. MYCETALES, Berk.—Deriving nutriment from the substance on which they grow, or from the surrounding medium. Fruit various in external character; spores either naked or con-

tained in utricles (*asci*), and then called sporidia, often definite, frequently of more than one kind, mostly producing a mucedinous mass of threads or cells (*mycelium*), from which the plant grows; impregnation at present uncertain. *Berk. l. c. p.* 235.

Div. 1. LICHENALES.—Aerial, deriving nourishment chiefly from the surrounding medium, and not from the substance on which they grow: constantly producing green cellules (*gonidia*) within their substance. Spores contained in asci, lodged in proper receptacles (*apothecia*). *Berk. l. c. p.* 372. (*Lichenales* are divided into two groups, or Orders? which are subdivided into fourteen families or sub-orders. *Berk. l. c. p.* 389.)

Div. 2. FUNGALES.—Parasitic, deriving nourishment, by means of a mycelium, from the substance on which they grow, and never producing from their component threads green cellules (*gonidia*). Spores naked or contained in asci.—*Berk. l. c. p.* 235. (Fungales are divided into six Orders (*Berk. l. c. p.* 269), which are subdivided into thirty families or sub-orders.)

Sub-class II. ALGALES, Lindl.—Cellular flowerless plants, without proper root or mycelium, living for the most part entirely under water, and imbibing nutriment by their whole surface from the medium in which they grow. Propagation various; sometimes by fissiparous division; sometimes by spores or zoo-spores, or by the mixing of the contents of two cells. Sexes often distinct on the same or on different individuals. Spermatozoids with one or more tail-like, vibratile appendages; very rarely, if ever, spiral. *Berk. l. c. p.* 84. (Algales (*Algæ* of authors) are divided into three series, *Berk. l. c. p.* 108, which are subdivided into thirty-two families or Orders.)

GENERAL REMARKS ON DISTRIBUTION OF PLANTS.

Geographic distribution of Species. Centres of Creation. Explanation of terms Fauna and Flora, Restricted Faunas and Floras, Local Faunas and Floras. Differences between Variety, Species. Extinct Species, Introduced Species, Causes of Extinction.

ECONOMIC BOTANY.

General Principles of Plant Life. Various Systems of which Plants are composed—Cellular System, Vascular System. Uses of Plants economically.

Edible Seaweeds—Dulse, Sloke or Laver, Carrigeen, Yeast Plant. Iodine, its history, preparation. Kelp.

Edible Lichens—Tripe de Roche, Iceland Moss, Reindeer Moss. Tinctorial Lichens; general history of subject—brown dyes, yellow dyes, purple and blue dyes, Orchil, Cudbear, Litmus. Weeds and Mosses. *Rocella Tinctoria.*

Plant Dyes. Colorific and Colorifiable products. Substantive and Adjective Colours—Indigo, Logwood, Weld, Fustic.

Production of Starch, Sugar, Gums, in Vegetable Tissues. Organic Elements.

Sago Palm, the history of preparation, Sago derived from other sources. *Cycas revoluta.* Other Starch compounds—Cabbage Palm, Betel Palm, Catechu, Date Palm, Oil Palms, Cocoa Palm, Cocoa Nut, Coir, Piasava, Jaggery, Arrack, Cocoa Nut Oil, Guinea Oil, Wax Palms, Resin Palms, Coquilla Nuts, Vegetable Ivory, Rattans, Cable Cane.

Resins and similar products.

Fossil Conifers; Amber, New Zealand Amber. Recent Conifers; Timber Trees—Larch, Pine, Spruce, Kaurie Pine, Norfolk Island Pine, Cedar, Red Cedar. Turpentines, modes of procuring. Resin, Pitch, Tar, manufacture of. Bark Bread of Norway. Stone Pine of Europe.

Woody Fibre. Chinese Grass Cloth. Common Hemp, Indian Hemp and its products; General account of manufacture of Hemp. Flax and its preparation. Sunn Hemp. Jute, Paat, Bast. Manilla Hemp. Pita Flax. Common Mallow. *Hibiscus Cannabinus.* Cellular tissue used for textile purposes. Cotton, its Manufactures.

Latex Laticiferous Vessels.

Antiaris Saccidora. Ant. Toxicaria. Paper Mulberry, Fustic. Caoutchouc, sources whence derived, its history, mode of preparation. Sabadilla Tribe—Gutta Percha Tree, its history, uses.

Vegetable Oils, receptacles of Secretion.

Manufacture of Olive Oil, Lucca Oil. Rape Oil. Fixed Oils—Hemp Oil, Linseed Oil, Poppy Oil, Cocoa Nut Oil, Palm Oil, Solid Oils, Volatile or Essential Oils. Oil of Lavender, Oil of Spike. Oil of Cassia, Oil of Cinnamon. Natural History and preparation. Camphor Tree, Borneo Camphor, Dutch Camphor. Moluccas Nutmegs, South American Nutmegs. Oil of Cloves, Oil of Anise. General History of Spices.

Cerealia; Natural history of. Parts of Plants used as food —fruit, leaf, stem, root, seed—Examples of. Conclusion.

Books recommended as Class Books:—Asa Gray's Botanical Text Book. Lindley's School Botany. Bentham's Handbook of the British Flora. Berkeley's Introduction to Cryptogamic Botany.

GEOLOGY.

Professor, J. Beete Jukes

Divided into:—

A. Physical Geography.

B. Geognosy.

C. Palæontology.

D. History of the formation of the Crust of the Earth.

PHYSICAL GEOGRAPHY.

Part I.

1. Form of the Earth, its Specific Gravity and Internal Heat.

Question as to Fluidity or Solidity of Interior.

2. Unevenness of the Surface of the Earth—Hollows, or Depressions below a certain level, filled with water and called Seas and Oceans—Elevations above that level form Dry Land—Comparison of the Area, the Shape or Contour, and the "Mould" or general form of the Land and of the bed of the Ocean—Mean Height of the Land, and Mean Depth of the Sea.

3. Land may be portioned out into Mountains and Hills, Table Lands, Plains, and Valleys. Mountains occur either Singly, or in Groups, Ranges, or Chains. Valleys among Mountains become Glens or Ravines.

4. Mountain Chains are composed of one range, or of two or more nearly parallel ranges, sometimes inosculating, sometimes divergent, sometimes connected, sometimes unconnected—and of lateral spurs running nearly at right angles to Chains.

Inosculating ranges enclose isolated Table Lands, or mountain Valleys; other ranges are separated or traversed by longitudinal and lateral Valleys.

5. Valleys connected together, so as to form a system of channels for conveying water into one central artery, producing a number of tributary streams to one main river.

Each system of Valleys forms a "Basin of Drainage." Basins of Drainage, separated by "water sheds," or ridges more or less abrupt, of elevated ground, from which the brooks fall each way.

Most Basins of Drainage empty themselves either directly or indirectly into the Ocean. Some are independent, and form Inland Seas or Salt Lakes, often called Caspians. Description of most remarkable Basins of Drainage.

6. Mountain Chains may be classed as Principal and Subordinate—Two Principal Mountain Chains, *a*. Indo-European Chain of Old World, running nearly East and West, *b*. Andes and Rocky Mountains of New World, running nearly North and South—Subordinate Chains numerous. Description of most remarkable Mountain Chains. Shape of Lands governed by direction of Principal and Subordinate Chains, slope of Plains and Valleys depending on Mountain Chains as axes of elevation.

Relation of the two principal Mountain Chains and their River Basins to the two great Oceans, the Atlantic and Pacific.

7. The Atmosphere and the Sea—their Physical and Chemical Constitution, extent, weight, colour, temperatures, and movements. Distribution of Solar heat, vertically and laterally; Isothermal lines; Cold in upper regions of Atmosphere; Snow line. Evaporation and condensation of Moisture, expansion and condensation of Air,—consequent circulation in Atmosphere and Ocean, causing Winds and Currents,—fluctuations in these caused by obliquity of Earth's axis to its orbit, and by unequal distribution of land,—deflections in their direction caused by Earth's rotation on its axis;—hence Rainy and Dry seasons and districts, Clouds, Rain, Hail, Snow, Glaciers and Icebergs, Land and Sea Breezes, Trade Winds, Monsoons, Calms, Tyfoons, Cyclones, Oceanic Currents, Gulf Stream, &c.

8. Climate—depending on Latitude, on distribution of Land and Water, on the proximity, height, direction, and aspect of slope of Mountains, and on the direction of Winds and Currents. Climate of Western Coast of Europe contrasted with that of Eastern Coast of North America—West Coast of North America contrasted with East Coast of Asia. Climates of South America and Australia described and accounted for and compared with each other and that of South Africa.

Deserts of Old and New World accounted for according to Maury's Theory of the Circulation of the Winds.

9. Geographical distribution of Animals and Plants laterally into Provinces, and vertically into Zones—Specific and Generic Centres—Homoiozoic Belts,—Present distribution the result of long continued action of various causes.

PART II.

10. Geological action of Moving Water—Mechanical action in disintegrating and transporting Mineral Matter—Springs, Rain, Ice, Brooks and Rivers, Cataracts and Waterfalls, formation of Deltas, transport of Rock by Glaciers and Icebergs—Formation of Ravines, Glens, and Valleys which are closed at one end—Erosive action of Sea Breakers and carrying power of Tides and Currents—Formation of Cliffs, Precipices, and Passes open at both ends—Deposit of Mud Banks and Sand Banks, and shallowing of narrow Seas.

Absence of Mechanical Deposits in bed of great Ocean—Soundings in North Atlantic—Infusorial Clay.

Chemical action in Dissolving Mineral Matter, as Silica, Carbonate of Lime, Salt, Gypsum, Iron, &c.—Hot Springs or Geysers, Petrifying Wells and Springs, Tufa, Travertine, Stalactites in Caverns—Conveyance of Dissolved Minerals into the Sea—Origin of the Saltness of the Ocean and of Caspians or Inland Seas—Plains and Valleys of Ireland, formed by Chemical and Mechanical action of Water on Dry Land.

11. Coral Reefs, their form, their extent, and distribution—Proof of the Origin of Limestone in the Organo-Chemical Action of Animals on the Carbonate of Lime dissolved in the Sea—Vertical thickness and steepness of Coral Reefs—Proof of Depression of the Ocean Bed.

12. Volcanoes and Earthquakes—Structure of a Volcanic Mountain—Cone and Crater—Ashes, Cinders, and Lava—Von Buch's elevation theory unnecessary and untrue—Subaerial and Submarine Volcanoes—remarkable Volcanic Eruptions—Active and Extinct Volcanoes—Distribution of Volcanoes—Connexion of Earthquakes and Volcanoes—Examples of remarkable Earthquakes—The Phenomena accompanying them—Mr. Mallett's Catalogue and Descriptions—Origin of Volcanic action.

13. Permanent elevation and depression of land during Earthquakes, but not caused by them—Gradual elevation and depression of land without Earthquakes—Examples of each kind of motion in our own times.

The existence of Dry Land, that is of Rock once below and now above the level of the sea, due entirely to the action of elevatory forces such as are now at work.

14. Proofs of the Physical Geography and Climate of the British Islands and Western Europe having been formerly different from what they are now, the Mountains having been covered by perpetual Snow, with Glaciers, although during part of the time the land stood at a lower level than it now does, and was consequently to a great extent covered by the Sea which was then encumbered with Icebergs—Arctic Shells then in the Irish Sea. Raised beaches and submarine forests and peat bogs. Extinct species of animals and ancient races of Men. Flint implements.

GEOGNOSY.

Subdivision of Geognosy into Lithology and Petrology.

Part I.—Lithology,

Or the study of the Mineral composition and intimate structure of Rocks, based on Mineralogy. Definition of the terms "Mineral," and "Rock."

1. Enumeration of the Substances which enter most abundantly into the composition of Rocks.

One simple substance—*Carbon*, in the Minerals—Diamond and Graphite, and in the Rock—Coal.

One Primary Compound—*Silica*, in the Mineral—Quartz.

The following Secondary Compounds or Salts:—*Carbonates*, Calcite, Dolomite—*Sulphates*, Gypsum, Anhydrite—*Silicates*, the Hornblendes, the Micas, the Feldspars, and the Zeolites.

2. Crystallization of Minerals:—Original fluidity of crystallized Minerals either from *solution* or *fusion*. Therefore all rocks formed of crystallized Minerals were either precipitated from solution, or consolidated from fusion. Crystalline rocks composed of *soluble* minerals are Aqueous, those composed of insoluble but *fusible* minerals are Igneous. These, whether aqueous or igneous, may be called *Chemically* formed Rocks.

3. Rocks composed of rounded or triturated *fragments* of Minerals are deposited from mechanical suspension in Water or Air, and may therefore be called *Mechanically* formed Rocks. They are principally Aqueous, the exceptions being Aerial.

4. Rocks composed of fragments of animals or plants, may be called *Organically* formed Rocks. These are either Aqueous, or Terrestrial in origin.

5. Rocks altered by Heat or other agency from their original condition, may be called *Metamorphic* (or transformed) Rocks.

6. Description of Rocks :—

IGNEOUS ROCKS. Principally *chemical* compounds, but having some *mechanical* accompaniments.

Cindery, glassy, slaggy, stony, and porphyritic structures.

Volcanic. Trachytes, or purely feldspathic Lavas, with Obsidian and Pumice. Clinkstone.
Dolerite, or Augitic Lavas, feldspar mingled with augite, &c. Basalt.
Intermediate Lavas, or Trachy-dolerite.
Tuff and Peperino, or Volcanic Ashes, breccias and conglomerates.

Trappean. Felstone, or siliceo-feldspathic trap.—Clinkstone.
Greenstone, or hornblendic trap, feldspar mingled with hornblende, &c.—Basalt—Amygdaloid.
Intermediate traps—Porphyry, Syenite.
Trappean Ashes, tuffs and breccias, or conglomerates.

Granitic, or super-silicated Rocks.

Elvanite—feldspar and quartz only.	
Pegmatite	do.
Eurite	do.
Syenite	do. with hornblende.
Granite	do. with mica.

Deep formed or hypogenous, no ashes.

7. AQUEOUS ROCKS. Principally mechanical, but many chemical, organic, or mixed.

Mechanical.	*Arenaceous.*	Sand, Gravel, Sandstone, Gritstone, Flagstone, Freestone, &c., Breccia, Conglomerate.
	Argillaceous.	Mud, Clay, Loam, Shale, Marl.
Chemical.	————	Gypsum, Rocksalt, Magnesian limestone.
Organic.	*Calcareous.*	From animals, Limestone, Chalk Oolite, Shell Marl, &c.
	Carbonaceous.	From plants, Coal, Lignite, Peat, &c.

Mingling and union of the mechanical, chemical, or organic forces in the production of many varieties of rock.

8. AERIAL ROCKS. Blown Sand and other accumulations, incoherent or concreted. Soil or mould.

Volcanic Tuff, &c., from ashes falling on land.

9. METAMORPHIC ROCKS. Igneous or Aqueous Rocks, altered by Heat, Pressure, or by Chemical action.

Arenaceous. Quartz rock, or quartzite, &c
Argillaceous. Clay-slate, &c.,
Calcareous. Statuary and other marbles. Dolomite.
The Schistose Rocks. Micaschist, Chloritic,—Talcose,—Hornblendic,—and other schists, Gneiss.

10. Concretionary, nodular, fibrous, and radiated structures, and segregation of mineral matter. Flint in Chalk, Chert in Limestone, &c. Balls and crystals of Iron Pyrites, and other minerals, in nests and geodes, and drusy cavities.

11. Decomposition and weathering of rocks. Percolation of water containing carbonic and other acids. Substitution and replacement of minerals. Petrifaction and mineralization of organic and other bodies.

Part II.—Petrology.

Or the study of Rock Masses.

1. Lamination and Stratification; extent and termination of beds; irregular and oblique lamination and stratification; current mark or ripple; contemporaneous erosion and filling up; beds on same horizon not always contemporaneous; interstratification, association and alternation of beds; lateral changes in lithological characters of beds; nomenclature of groups of beds; lateral and vertical changes the natural result of mode of formation of Aqueous rocks.

2. Joints, Cuboidal and Prismatic; master joints; face, slyne, or cleat in coal; columnar structure; origin of joints; natural and artificial removal of rock in consequence of joints. Art of Quarrying.

3. Movements of disturbance in Earth's crust; permanent change of level between land and sea a result of motion first in the *solid* not in the fluid; movement of rock proved by inclination of beds; two modes of action in movements of disturbance.

4. Inclination of beds, dip and strike of beds, geological maps and sections, contortions, anticlinal, synclinal, and uniclinal curves, quâ-quâ-versal dip, basins and domes, inversion of beds. Artesian wells.

5. Faults or dislocations; upthrow, downthrow; false appearance of lateral shift; relation between inclination and throw of faults; trough faults; lateral pressure; connexion between faults and contortions, laterally and vertically; simultaneous occurrence of faults and igneous rocks the exception not the rule.

6. Cleavage and foliation; origin of cleavage; difference between cleavage and foliation; cleavage and foliation of Leinster and Munster.

7. Denudation, or production of a new surface on rocks; amount of erosion equal to that of deposition; marine and atmospheric denudation; the "form of ground" due chiefly to atmospheric denudation; hills and valleys formed by denudation only; denudation proved by outcrop of beds, by escarpments, and outliers; instances of denudation in Ireland, plains and valleys caused by atmospheric denudation; inconceivable time required for it; denudation during different geological periods.

8. Unconformability and overlap; overlap the result of successive depression; unconformability is deposition of fresh beds on previously denuded surface; practical importance of subject. Structure of Co. Dublin explained.

9. Granitic or Hypogenous rocks; fundamental granite; primæval granite or primitive rocks not known to be now in existence; position and form of granitic masses; granite naturally associated with older rather than newer rocks; relative age of granitic masses proved by that of their denudation; granite veins; original irregularities in surface of deep-seated granite mass and varied surface appearance produced by denudation.

10. Trappean rocks; form and mode of occurrence; distinction between contemporaneous and intrusive trap; traps and ashes of Lower Silurian rocks in N. Wales and S. Ireland; traps and ashes of Carboniferous rocks of Limerick basin; association of felstone and greenstone; trap dykes and veins; plateaux of basalt; basalt and ash of Co. Antrim.

11. Volcanic rocks; form and mode of occurrence; dykes and veins of lava; association of trachyte and dolerite; volcanoes the external manifestation of motion and disturbance in the molten trappean and molten granitic masses below.

12. Orography, or structure and origin of mountains; relation between intrusion of igneous and elevation of stratified rocks; high inclinations always communicated to beds at some considerable depth, and never near the surface; Mountains are of three kinds—*a.* of circumdenudation, *b.* of uptilting, *c.* of ejection; valleys are of one kind only; intercolline spaces; E. de Beaumont's theory of the parallelism of mountain chains only partially true.

13. Mineral veins; metallic ores occurring in beds; pipe veins; true lodes or rake veins; auriferous veins; stream works or diggings; modes of deposition of minerals in veins; association of minerals in veins; relation between contents of veins and nature of surrounding rocks; fallacious appearance of connexion between mineral veins and igneous rocks.

14. Art of Mining; bed mining,—long wall method,—post and stall method; vein mining.

PALÆONTOLOGY.

The Zoology and Botany of the past, or the study of Fossils.

1. Fossils are the remains, or any recognisable traces or impressions of animals and plants buried in the earth by any other than human agency.

2. Petrifaction is the mineralization, more or less complete, of a body once entirely organic.

3. Kinds of animals and plants most likely to be found fossil. Among vegetables the terrestrial are most numerous, but among animals the aquatic kinds. Terrestrial animals and plants must be comparatively rare in aqueous rocks; while aquatic animals having shells, or other hard parts capable of preservation, such as Reptiles, Fish, testaceous Mollusca, Crustacea, Echinodermata, and Corals, must be most numerous.

4. The marine testaceous Mollusca afford the most complete and unbroken scale of chronological comparison. Those found fossil in the British Islands are nine times more numerous than those living in the British Seas. There must therefore, probably be, at least, nine extinct populations. or portions of more than nine, each as numerous as the existing one, buried in the rocks of our islands.

5. Fossils are found in groups or assemblages, each group having a peculiar "facies," and varying in species both laterally and vertically; first, according to the conditions of depth and nature of place of deposit: and secondly, according to the extinction of old, and the introduction of new species.

6. In the age immediately preceding our own, the geographical distribution of orders and genera of animals was the same as that now existing; and similar laws seem always to have regulated the distribution of life on the globe.

7. Law of approximation to living forms apparent throughout the known series of fossil groups.

8. The extinction of species is most probably the result of the action of hostile tribes, of surrounding circumstances becoming unfavourable, either gradually or suddenly, and of the occurrence of "murrains" or "blights"—not of any decay in the species, like old age in the individual.

9. The introduction of species is the result either of direct creation or of some physiological law. Darwin's doctrine of Natural Selection best explanation ever yet attempted.

10. As a consequence of the succession of forms of life, fossils have a chronological significance, and enable us to determine the date of production of the rocks enclosing them, and therefore their relative order of formation and

their superposition; and this can be done either from experience, or by reasoning *a priori* from their "facies."

Some species, having been short-lived, are found through but a narrow vertical series of beds; others, more hardy or more flexible in constitution, lived through longer periods, and are found through whole formations, a few even in more than one formation. Some persistent types very slightly modified since earliest geological periods.

11. Sudden destruction of whole races, and introduction of new assemblages of life highly improbable; the appearance of sudden change probably due to the imperfection of our records and the absence of a great number of beds in an apparently continuous series of deposits.—Barrande's Doctrine of Colonies.

12. Question of climate as determined by organic remains of different regions.

HISTORY OF THE FORMATION OF THE CRUST OF THE GLOBE.

Terms applicable either to periods of time, or to the rocks formed in those periods. This ambiguity a frequent source of confusion and mistake.

Some terms derived from nature of rock, some from geographical situation of rocks, some from relative date of formation.

Dismissing the derivation of terms—consider the following as signifying only *periods of time*, following in succession, and divided into three great epochs.

	PRIMARY OR PALÆOZOIC EPOCH.	
	Præ-Cambrian	periods.
a.	Cambrian	period.
b.	Cambro-Silurian	"
c.	Upper Silurian	"
d.	Devonian	"
e.	Carboniferous	"
f.	Permian	"
	SECONDARY OR MESOZOIC EPOCH.	
g.	Triassic	period.
h.	Oolitic or Jurassic	"
i.	Cretaceous	"
	TERTIARY OR KAINOZOIC EPOCH.	
j.	Eocene	period.
k.	Miocene	"
l.	Pliocene	"
m.	Pleistocene	"
n.	Recent or Historical	"

Proposed modification by Professor Edward Forbes into two epochs only, namely, Palæozoic and Neozoic.

Description of Particular or Typical Groups of Rocks formed during the above periods, and of their most characteristic Fossils, according to the following abstract.

PRIMARY OR PALÆOZOIC EPOCH.

Præ-Cambrian Periods.

(Vaguely known,)

Scotland.—Lewisian gneiss of Sir R. I. Murchison.

N. America.—Laurentian gneiss, &c., of Sir W. Logan. Probably much gneiss and metamorphic rocks in other parts of the world.

a. Cambrian Period.

Fossils.—Oldhamia. Annelid tracks and Fucoids.

Typical Groups of Rocks.

Wales.—Longmynd, Barmouth and Harlech, and Anglesea Rocks.

Ireland.—North Wicklow and South Wexford Rocks.

Scotland.—Red sandstone and conglomerate of Sutherland, &c.

Bohemia.—Stage A, Crystalline Schists; and Stage B, Argillaceous Slate and Conglomerate (Barrande).

N. America.—Huronian series, perhaps Taconic system in part.

b. Cambro- (or Lower) Silurian Period.

Middle and Upper Cambrian of Professor Sedgwick.

Fossils.—Peculiar species of Corals and other Zoophytes, Echinodermata, Crustacea (Trilobites), Brachiopoda, Lamellibranchiata, Gasteropoda and Cephalopoda. Cystidea, Crinoidea and Strophomenidæ very abundant.

Typical Groups of Rocks.

Wales.—*b* 1. Lingula Flags. *b* 2. Llandeilo beds. *b* 3. Caradoc Sandstone and Bala beds. *b* 4. (?) Lower Llandovery beds.

Bohemia.—*b* 1. Stage C of Barrande, argillaceous slate. *b* 2. Stage D of Barrande, quartzites.

North America.—*b* 1. Potsdam Sandstone. *b* 2. Calciferous Sandstone. *b* 3. Chazy Limestone. *b* 4. Birdseye Limestone. *b* 5. Black River Limestone. *b* 6. Trenton Limestone. *b* 7. Utica Slate. *b* 8. Lorraine Shales and Sandstones, or Hudson River group.

c. Upper Silurian Period.

Fossils.—Peculiar species of animals of the classes mentioned above, and gigantic Crustacea and Fish in addition. The species generally different from those living in the preceding or succeeding periods. Some species found only in one of the typical groups.

Typical Groups of Rocks.

England.—c 1. Llandovery Rocks, including the Upper Llandovery Sandstone or Mayhill Sandstone, and the Tarannon Shales. *c* 2. Wenlock group, Shale and Limestone. *c* 3. Ludlow Rocks, with Aymestry Limestone. *c* 4. Tilestone.

Bohemia.—*c* 1. Stage E, Calcaire inferieur. *c* 2. Stage F, Calcaire Moyen. *c* 3. Stage G, Calcaire superieur. *c* 4. Stage H, Schistes culminants (Barrande).

North America.—*c* 1. Grey Sandstone. *c* 2. Oneida conglomerate. *c* 3. Medina Sandstone. *c* 4. Clinton group. *c* 5. Niagara group. *c* 6. Onondaga Salt group. *c* 7. Tentaculite Limestone. *c* 8. Pentamerus Limestone. *c* 9. Delthyris Shaly Limestone. *c* 10. Encrinal Limestone. *c* 11. Upper Pentamerus Limestone.

d. Devonian Period.

Fossils.—Some Plants, and many very remarkable Fish, in addition to other and peculiar species of animals belonging to the classes mentioned before.

Typical Groups of Rocks.

(Much uncertainty as to the groups of this period.)

Devon and Cornwall.—*d* 1. Liskeard or Ashburton group. *d* 2. Plymouth group. *d* 3. Dartmouth group. The Marwood and Barnstaple Rocks, and Petherwin group, belong to the Carboniferous period.

South Wales and Hereford.—Old Red Sandstone. *d* 1. Cornstone group, Red Marl and Sandstone with calcareous bands. *d* 2. Red and Brown Sandstone and Conglomerates, with Yellow Sandstones in upper portion; the latter probably Carboniferous.

Scotland.—Old Red Sandstone in three subdivisions. *d* 1. Caithness group. *d* 2. Grey Sandstone. *d* 3. Red and Yellow Sandstone, with concretionary Limestone; the latter probably Carboniferous.

Ireland.—Possibly the Dingle Beds, consisting of Red and Green Grits and Slates, and Red Conglomerates, and also some called Old Red Sandstone. *d* 1. Lower Beds, Red, Green, and Purple Sandstones and Slates, with massive Grits, (Glengariff Grits), with calcareous bands or Cornstones, and occasional Conglomerates. *d* 2. Upper Beds, or Yellow Sandstone, Red, Brown, and Yellow Sandstones, with Red, Brown, and Green Shales or Slates, with occasional Cornstones and Conglomerates; the latter probably Carboniferous.

The Rhine.—*d* 1. The Coblentz group. *d* 2. The Ahr group. *d* 3. The Eifel group.

North America—*d* 1. Oriskanny Sandstone. *d* 2. Cauda-Galli and Schoharrie Grit. *d* 3. Onondaga and Corniferous group. *d* 4. Marcellus Shales. *d* 5. Hamilton group. *d* 6.

Tully group. *d* 7. Gennessee and Portage group. *d* 8. Chemung group. *d* 9. Catskill group, or Old Red Sandstone.

e. Carboniferous Period.

Fossils.—A vast abundance of Plants—Ferns, and Forest Trees, and others of unknown affinities. Peculiar species of all the classes of animals mentioned before, with several Reptiles. The Cephalopoda especially numerous, and some of them (as Orthoceras) gigantic. Crinoidea, Productidæ, and Spiriferidæ very abundant.

Typical Groups of Rocks.

Ireland.—*e* 1. Carboniferous Slate, with Coomhola Grits in its lower portion. *e* 2. Lower Limestone Shale. *e* 3. Lower Limestone. *e* 4. Calp. *e* 5. Upper Limestone. *e* 6. Millstone Grit. *e* 7. Coal-measures.

South Wales.—*e* 1. Lower Limestone Shale. *e* 2. Carboniferous Limestone. *e* 3. Millstone Grit, or Farewell Rock. *e* 4. Coal-measures.

Derbyshire.—*e* 1. Carboniferous Limestone. *e* 2. Upper Limestone Shale. *e* 3. Millstone Grit. *e* 4. Coal-measures.

York and Durham, &c.—*e* 1. Great Scar Limestone. *e* 2. Yoredale Series. *e* 3. Millstone Grit. *e* 4. Coal-measures.

Scotland.—*e* 1. Calciferous Sandstone (Maclaren). *e* 2. Lower or Thick Limestone with Shales and Coals—Great Scaur Limestone of Yorkshire. *e* 3. Lower Coals and Upper Limestones—Yoredale Rocks of Yorkshire. *e*. 4. Moor Rock or Rosslyn Sandstone—Millstone Grit. *e*. 5. Upper Coals—Coal-measures.

f. Permian Period.

Fossils.—Peculiar species of most of the classes mentioned before, (no Trilobites,) Fish abundant in the Magnesian Limestone and Zechstein Group.

Typical Groups of Rocks.

Perm in Russia, and Germany.—*f* 1. Rothetodtliegende. *f* 2. Zechstein and Kupfer schiefer. *f* 3. Lower Bunter Sandstein.

Durham and Yorkshire.—*f* 1. Lower Red Sandstone. *f* 2. Magnesian Limestone.

SECONDARY, OR MESOZOIC EPOCH.

g. Triassic Period.

Fossils.—Very imperfectly known hitherto; mostly footprints of large Batrachian and other Reptiles in Britain; many shells, &c., of peculiar species in the Muschelkalk. Mingling of Palæozoic and Mesozoic types, and of some genera of intermediate character in the St. Cassian beds. Fish and Saurian Reptiles in Germany. A Mammal in the Keuper.

Typical Groups of Rocks.

Germany.—*g* 1. Bunter Sandstein. *g* 2. Muschelkalk. *g* 3. Keuper.

Hallstatt, and St. Cassian beds.

England.—*g* 1. Bunter Division, consisting of Lower Red and Mottled Sandstone; Conglomerate or Pebble beds; and Upper Red and Mottled Sandstone. *g* 2. Keuper Division, consisting of White and Brown Sandstone (Water-stones), with beds of Red Marl; and Red and Mottled Marl, with Rock Salt and Gypsum.

h. Oolitic, or Jurassic Period.

Fossils.—Peculiar species of Plants, Corals, Echinodermata, and of all other classes of marine animals which have any hard parts. Proportionate diminution in numbers of Brachiopoda, and increase in those of Conchifera and Gasteropoda. Large Marine and Terrestrial Saurian Reptiles, very abundant in the Lias; some winged Reptiles; some Insects; footprints of Birds in America; and several small Terrestrial Mammalia (Marsupial and Placental.)

Typical Groups of Rocks.

South England.—(Lias) *h* 1. Bone bed. *h* 2. Lower Lias Shale and Limestone. *h* 3. Marlstone. *h* 4. Upper Lias Shale and Sands.—(Lower Oolitic or Bath Group) *h* 5. Inferior Oolite. *h* 6. Fuller's Earth. *h* 7. Great Oolite. *h* 8. Forest Marble. *h* 9. Cornbrash.—(Middle Oolitic, or Oxford Group) *h* 10. Oxford Clay. *h* 11. Coral Rag.—(Upper Oolitic, or Portland Group) *h* 12. Kimmeridge Clay. *h* 13. Portland Sand and Stone. *h* 14. Purbeck Beds.

h 13 and *h* 14 are wanting in Yorkshire, and *h* 11, the Coral Rag, is wanting at many places between Yorkshire and Gloucestershire.

Yorkshire.—(Lias) *h* 1. Lower Lias Shale. *h* 2. Marlstone. *h* 3. Upper Lias Shale.—(Lower Oolitic Group) *h* 4. subcalcareous ferruginous Sand. *h* 5. Sandstone, Shale, Ironstone, and Coal. *h* 6. Impure Oolitic Limestone. *h* 7. Sandstone, Shale, Ironstone, and Coal. *h* 8. Shelly Limestone, Cornbrash.—(Middle Group) *h* 9. Oxford Clay. *h* 10. Coral Rag.—(Upper Group) *h* 11. Kimmeridge Clay.

Carboniferous aspect of Lower Oolite Group in many places.

i. Cretaceous Period.

(The line of demarcation between this and preceding period rather doubtful; but the Wealden beds are hardly of importance enough to require a period to themselves.)

Fossils.—In the fresh water beds, many Plants and fresh water and estuary Shells, skeletons of gigantic Terrestrial Reptiles. In the marine beds species of all classes of

animals that had any hard parts except Mammals, no remains of which have yet been found. Echinoidea and curiously formed cephalopodous shells with corrugated septa, especially abundant in the Chalk.

Typical Groups of Rocks.

England, France, Belgium, &c.—(Lower Cretaceous or Neocomian). *i* 1. Wealden group, consisting of Hastings Sand and Weald Clay. *i* 2. Lower Green Sand. ? Speeton Clay of Yorkshire.—(Upper or true Cretaceous). *i* 3. Gault. *i* 4. Upper Green Sand. *i* 5. Chalk Marl. *i* 6. Chalk without flints. *i* 7. Chalk with flints. *i* 8. Maestricht or Pisolitic chalk.

Neufchatel, &c.—The Neocomian limestones and clays represent the Lower Green Sand, and perhaps the Wealden beds, which, as a mere fossil delta of some great river, ought to be referred to their contemporaneous marine beds.

North Germany, &c.—Quadersandstein and Pläner kalk represent part of the Chalk of other countries.

North America.—Sandstones and Shales with beds of coal.

South America.—Some of the Cretaceous Rocks are blue clay slate.

KAINOZOIC, OR TERTIARY EPOCH.

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k. Eocene Period.

Fossils.—Many Plants—Palm Fruits in the Island of Sheppey. Peculiar species of almost every class of animals, without exception, including Birds and Mammals. Of the Shells, few are Brachiopoda, of the other Shells a few (not more than five per cent.) are still living at the present day. Many extinct Mammalia in France, found in the fresh-water beds. Turtles and Crocodiles in London Clay, &c. Nummulites very abundant in Southern Europe and Asia, or on southern side of the great Indo-European chain.

Typical Groups of Rocks.

Middlesex and Hampshire.—(Lower Group.) *k* 1. Thanet Sands. *k* 2. Woolwich Beds, or Plastic Clay. *k* 3. London Clay. (Middle group), *k* 4. Bagshot, Bracklesham, and Barton Beds. *k* 5. Headon Beds. *k* 6. Osborne series. (Upper group), *k* 7. Bembridge Beds. *k* 8. Hempstead Beds. (*k* 8 is perhaps Miocene.)

North France.—(Lower Group.) *k* 1. Sable de Bracheux. *k* 2. Argile Plastique. *k* 3. Lignites des Soissonnais. (Middle group), *k* 4. Lits Coquilliers. *k* 5. Calcaire Grossier, and Glauconie Grossier. *k* 6. Sables Moyennes. *k* 7. Gres de Beauchamp. *k* 8. Calcaire de St. Ouen. (Upper group),

k 9. Gypseous series of Montmartre, in three bands of Gypsum, interstratified with Marls and fresh-water Limestone: Calcaire silicieux. *k* 10. Fontainebleau Sands. *k* 11. Calcaire de Beauce. (10 and 11 are perhaps Miocene.)

In these two series, the Hempstead Beds=Fontainebleau Sands; the Bembridge Beds=Montmartre Gypsum; the Calcaire Grossier=Bracklesham Beds; the Lits Coquilliers=Lower Bagshot Sands; the Lignites des Soissonnais=Fluviatile Beds of Woolwich; and Sable de Bracheux=Lower Woolwich Beds. The London Clay and Thanet Sand have no representatives in France, (Prestwich).

l. Meiocene Period.

Fossils.—Shells, of which about eighteen or twenty per cent. are still living. Extinct Mammalia, such as the Deinotherium, Sivatherium, Mastodon, &c.; probably Plants associated with basalt of Scotland and North of Ireland.

Typical Groups of Rocks.

France.—The faluns of Touraine, the Bourdeaux Beds, perhaps the Fontainebleau sands, and the Calcaire de Beauce.

Great Lakes and Volcanoes in central France—Volcanic Cones and Lava Streams still preserved, many of these, however, probably belong to a subsequent period.

Germany.—Mayence Basin, and Vienna Basin.

Belgium.—Bolderburg and Limburg Beds.

Switzerland.—The Molasse.

Italy.—Part of the Sub-Appenine Beds.

Britain.—Perhaps the Hempstead Beds, and probably the Basalt of N. Ireland, and W. Scotland.

North America.—Beds of North Carolina, Maryland, Virginia, and Delaware.

India.—The Sewalik Beds.

m. Pleiocene Period.

Fossils.—Shells of which 50 to 70 per cent. are still living, Bones of whales and of numerous Terrestrial Mammalia.

Typical Groups of Rocks.

England.—*m* 1. Coralline Crag. *m.* 2. Red Crag.

Italy.—Major part of Sub-Apennine Beds; Seven Hills of Rome.

Asia.—Aralo-Caspian formations.

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n. Pleistocene Period.

ils.—Shells of which 75 to 90 per cent. are still ther in the immediate neighbourhood of the places are found fossil or in other and sometimes dis-

tant localities. Mammalia in great abundance, owing chiefly to preservation of land surfaces. Mammoth, Mastodon, extinct species of Hippopotamus and Rhinoceros; Irish Elk, or Big Horn; gigantic Bears, Hyenas, Lions, and Tigers, &c., in Europe; Mastodon, &c., in North America; Megatherium, Mylodon, and Glyptodon, in South America. Many extinct species of Elephants, Camel-leopards, &c., in India; gigantic Kangaroos, Wombats and Wallabis in Australia, with one Mastodon; gigantic Emu-like Birds, Dinornis, &c. in New Zealand. Flint implements and human bones in caves and lacustrine deposits.

Typical Groups of Rocks.

England.—Mammaliferous Crag of Norwich. Glacial and other drifts. Marl of South of Ireland. Limestone gravel and Eskers of Central Ireland. Raised Beaches. Submarine Forests. Bone Caves. Lacustrine deposits.

Sicily.—Great formations several hundred feet thick and rising 3,000 feet above sea, although full of Shells of same species as those in Mediterranean.

The Rhine.—Loess and Lehm.

North America, and other countries.—Drift and superficial accumulations. Vegetable soil.

Applications of Geology to Agriculture best considered here.

o. Recent or Historical Period.

Fossils.—Still existing animals and plants. Human bones in beaches of coral sand, &c.

Typical Groups of Rocks.

Lacustrine formations. Peat bogs. Deltas of rivers. Coral reefs. Sand dunes. Mud banks, &c. Physical Geography of present day the result of operations continued through preceding periods, though a preliminary knowledge of it is necessary to understand geological action.

Class Book.—Student's Manual of Geology, by J. Beete Jukes, 12*s.* 6*d.*
Book for Perusal.—Lyell's Principles of Geology, 18s.

PRACTICAL CHEMISTRY.

Professor, Robert Galloway, F.C.S.L.

The Laboratory Course of Instruction is divided into:—

1. The Laws and Language of the Science.
2. Qualitative Analysis, with the use of the blowpipe.
3. Quantitative Analysis, including a complete course of Volumetrical Analysis

LAWS AND LANGUAGE OF THE SCIENCE.

First Course.

The laws of combination, the formation and decomposition of compound substances, the forces which promote, modify, or retard the chemical force, are taught in a series of experimental lessons. The nomenclature and notation of the science, the use of the different signs, as the comma and plus, the use of brackets, the construction of formulæ, the mode of expressing chemical changes, the method for determining the several constituents contained in a given quantity of any compound, are taught in a series of progressive exercises, which each student performs.

Class Book.—The First Step in Chemistry, by R. Galloway.

Second Course.

In the second part of the course, on the laws and language of the science, the following subjects are taught in a series of *progressive* and *practical* exercises:—The specific gravity of gases; the correction of gases for temperature, pressure, and moisture; combination by volume; atomic volumes; the specific gravity of vapours; application of the specific gravity of vapours to control the chemical analyses of substances; unitary notation.

Class Book.—The Second Step in Chemistry, by R. Galloway.

QUALITATIVE ANALYSIS.

Each student in this course performs a series of experimental exercises, which are calculated to make him practically acquainted with the *general* and *analytical* properties of the inorganic bases and acids, and some of the more commonly occurring organic acids. After he has performed the experiments on all the substances in a group, before he passes on to the next group, a series of analyses are given him on the group, and lastly on that and the previous groups. In this way the student is led, step by step, from the simplest to the most complicated cases of qualitative analysis.

The course is concluded by a series of practical exercises on the blowpipe characters of the most important and most frequently occurring minerals, and the qualitative analysis of soils, waters, ashes of plants, guano; the testings for poisons, &c.

Each student in the qualitative and quantitative courses works independently; there are no classes. A table, with drawers, cupboard, and shelves, is appropriated to each pupil, and he is supplied, free of any charge, with all apparatus and reagents.

Class Book.—Manual of Qualitative Analysis, by R. Galloway.

The advanced students will practise Bunsen and Kirchhoff's method of Qualitative Analysis by means of the spectrum.

QUANTITATIVE ANALYSIS.

Inorganic Analysis.

This course commences with the quantitative analysis of some of the simplest *chemical compounds*, such as chloride of sodium, carbonate of soda, sulphate of copper, &c., and extends to more complicated chemical compounds and the analysis *of mixtures*. The special part of the course will include the quantitative analysis of ores, manures, waters, &c.

A complete course of volumetrical analysis and commercial testing, including alkalimetry, acidimetry, chlorimetry, valuation of manganese ores, valuation of barks employed in tanning, estimation of alcohol in wines, beers, &c.; determination of the original gravity of beers; estimation of sugar by the polariscope; the assaying of ores; the analysis of urine, milk; the detection of poisons, &c.

ORGANIC ANALYSIS.—GAS ANALYSIS.

Practical instruction will be given in these departments of analytical chemistry to the more advanced students.

The students will have the use of the microscope as an aid in their chemical investigations.

FEES AND REGULATIONS.

There are both day and evening classes in operation in the chemical and metallurgical laboratories from October to June. There are in the Collegiate Year three laboratory sessions of three months each.

Day Instruction.

The laboratories are open, during the nine months, every day in the week, Saturday and the periods of the Christmas and the Easter recesses excepted; the hours of instruction are from 10, a.m., until 4, p.m. The pupils are not taught in classes, but individually; each student performs chemical analyses, both *qualitative* and *quantitative*, instructed and superintended by the Professor and the Assistant Chemist.

The charge for instruction is £8 for *nine* months; £7 for *six* months; £4 for *three* months; £2 for *one* month, *payable on registration*. The student is supplied by the institution, free of any further charge, with *all apparatus and reagents*. All apparatus broken or injured by the student will have to be paid for.

Evening Instruction.

The same system of instruction is carried out in the evening as in the day classes, and the students are individually

instructed and superintended by the Professor and the Assistant Chemist. The hours of instruction are from 7, p.m., to 9, p.m.

A junior evening class will be commenced on the 3rd of October, at 7, p.m., and a senior evening class on the 6th of October, at 7, p.m., and will be continued throughout the Collegiate Year, at the same hour every Monday and Wednesday for the senior class, and every Tuesday and Friday for the junior class.

The charge for instruction is £2 for nine months, and £1 for three months, *payable on registration.* The student is supplied, free of any further charge, with all apparatus and reagents.

PRACTICAL ZOOLOGICAL INSTRUCTION.

During the Session 1859-60 a special class for the more particular study of Zoology was instituted; the course of instruction including the lectures delivered during the months of October and December (vide page 7), and being divided as follows:—

1. Distributional Zoology.
2. Structural Zoology.
3. Classification and Distribution of Types.
4. Histology and the Microscope.

Courses 1 and 3 constitute the systematic course, and distinct examinations are held in them (vide pages 7 and 9).

DISTRIBUTIONAL ZOOLOGY.

The consideration of the distribution of types in space and time. Origin, formation and progress of Faunas. Laws which limit and govern animal distribution. Causes which operate to the extinction and spread of species.

This course will consist of twelve lectures, and be delivered in the Royal Dublin Society's theatre (vide page 6).

STRUCTURAL ZOOLOGY.

The relations, type forms, and modifications of the skeleton, and other organs of the several archetypes, illustrated by reference to the organs themselves, by lectures in the Museums, and (if practicable) in the field. The more remarkable and important fossil forms; their connexion with living types. The students will be afforded an opportunity of practising themselves in the demonstration of organs in such of the classes as are of most usual occurrence. This course will consist of seventeen lectures, and will be delivered during the month of November in the Class-room, Museum of Irish Industry.

CLASSIFICATION OF TYPES; THEIR RELATION AND DISTRIBUTION.

This course will commence early in the Session, as will be arranged by the Professor, and will continue under the same regulations as heretofore; the usual special examination in Zoology will be held at the end of the Course, under the usual regulations, in the subjects of the Lectures. Students entering for the courses in Structural Zoology and the Microscope, are free to this course. Other students pay the usual fee of 2*s*.

HISTOLOGY AND THE MICROSCOPE.

The structure and composition of the tissues, &c., composing the various organs, the lower forms of animal life, and the more remarkable changes which take place during the process of development. This course will be illustrated by demonstrations with the Microscope; and during its progress students will be required to make themselves familiar with the manipulation of the Microscope. The course will consist of sixteen lectures. The hours will be arranged as will best suit other arrangements. The lectures will be given in the Zoological Class-room, Museum of Irish Industry.

EXAMINATIONS.

An examination of the Zoological class will be held in February, 1863, in the *entire* subjects lectured on, at which certificates of proficiency will be awarded. Prizes will be also awarded, provided sufficient proficiency be shown.

The examination will extend over at least two days, one of which may be devoted to a purely *practical* examination.

These examinations will be open only to such students as may enter for the entire Zoological courses, on or before the 10th January.

FEES AND REGULATIONS.

The lectures on Structural Zoology will be delivered on every week day, except Saturday. The lectures on the Microscope in the evenings—Mondays, Tuesdays, Wednesdays, and Thursdays.

The fees for attendance on these lectures will be—£1 for the entire session, or ten shillings for each of the special courses, and two shillings for the course on classification.

EXCURSIONS.

Field excursions will be held on each Saturday during October, November, December, and January, weather permitting; the times and places to be announced each week.

TABLE OF THE DAYS AND HOURS OF LECTURE DURING THE SESSION.

OCTOBER.

Day of Month.	Day of Week.	Day Lectures, 4 p.m.		Evening Lectures, 8 p.m.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
2	THURSDAY,	—	—	Opening Address by Sir R. Kane, Director.	Museum of Irish Industry.
6	MONDAY,	Introductory Lecture by the Professor of Zoology.	Theatre of the Royal Dublin Society.	—	—
7	TUESDAY,	2nd Lecture on Zoology.	"	—	—
8	WEDNESDAY,	3rd do.	"	—	—
9	THURSDAY,	4th do.	"	—	—
10	FRIDAY,	5th do.	"	—	—
13	MONDAY,	6th do.	"	Opening Lect. by Prof. of Chemistry.	Museum of Irish Industry.
14	TUESDAY,	7th do.	"	2nd Lecture on Chemistry.	"
15	WEDNESDAY,	8th do.	"	3rd do.	"
16	THURSDAY,	9th do.	"	4th do.	"
17	FRIDAY,	10th do.	"	5th do.	"
20	MONDAY,	11th do.	"	6th do.	"
21	TUESDAY,	12th do.	"	7th do.	"
22	WEDNESDAY,	—	—	8th do.	"
23	THURSDAY,	Introductory Lecture by the Professor of Physics.	"	9th do.	"
24	FRIDAY,	2nd Lecture on Physics.	"	10th do.	"
27	MONDAY,	3rd do.	"	11th do.	"
28	TUESDAY,	4th do.	"	12th do.	"
29	WEDNESDAY,	5th do.	"	—	—
30	THURSDAY,	6th do.	"	—	—
31	FRIDAY,	7th do.	"	—	—

NOVEMBER.

Day of Month.	Day of Week.	Day Lectures, 4 p.m.		Evening Lectures, 8 p.m.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
3	MONDAY, .	8th Lecture on Physics.	Theatre of Royal Dublin Society.	Opening Lect. by Prof. of Geology.	Theatre Museum of Irish Industry
4	TUESDAY, .	9th do.	”	2nd Lecture on Geology.	”
5	WEDNESDAY,	10th do.	”	3rd do.	”
6	THURSDAY, .	11th do.	”	4th do.	”
7	FRIDAY, .	12th do.	”	5th do.	”
10	MONDAY, .	Introd. Lect. by Prof. of Chemistry,	”	6th do.	”
11	TUESDAY, .	2nd Lecture on Chemistry.	”	7th do.	”
12	WEDNESDAY,	3rd do.	”	8th do.	”
13	THURSDAY, .	4th do.	”	9th do.	”
14	FRIDAY, .	5th do.	”	10th do.	”
17	MONDAY, .	6th do.	”	11th do.	”
18	TUESDAY, .	7th do.	”	12th do.	”
19	WEDNESDAY,	8th do.	”	—	—
20	THURSDAY, .	9th do.	”	—	—
21	FRIDAY, .	10th do.	”	—	—
24	MONDAY, .	11th do.	”	Opening Lect. by Prof. of Zoology.	Theatre Museum of Irish Industry
25	TUESDAY, .	12th do.	”	2nd Lecture on Zoology.	”
26	WEDNESDAY,	—	—	3rd do.	”
27	THURSDAY, .	—	—	4th do.	”
28	FRIDAY, .	—	—	5th do.	”

DECEMBER.

Day of Month.	Day of Week.	Day Lectures, 4 p.m.		Evening Lectures, 8 p.m.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
1	MONDAY,	Introductory Lecture by Professor of Geology.	Theatre of Royal Dublin Society.	6th Lecture on Zoology.	Theatre Museum of Irish Industry
2	TUESDAY, .	2nd Lecture on Geology.	"	7th do.	"
3	WEDNESDAY,	3rd do.	"	8th do.	"
4	THURSDAY, .	4th do.	"	9th do.	"
5	FRIDAY, .	5th do.	"	10th do.	"
8	MONDAY, .	6th do.	"	11th do.	"
9	TUESDAY, .	7th do.	"	12th do.	"
10	WEDNESDAY,	8th do.	"	13th do.	"
11	THURSDAY, .	9th do.	"	14th do.	"
12	FRIDAY, .	10th do.	"	15th do.	"
15	MONDAY, .	11th do.	"	16th do.	"
16	TUESDAY, .	12th do.	"	17th do.	"
17	WEDNESDAY,	—	—	18th do.	"
18	THURSDAY, .	—	—	19th do.	"
19	FRIDAY, .	—	—	20th do.	"
22	MONDAY, .	—	—		
23	TUESDAY, .	Christmas Recess to January 5th.			
24	WEDNESDAY,				
25	THURSDAY, .				
26	FRIDAY, .				
29	MONDAY, .				
30	TUESDAY, .				
31	WEDNESDAY,				

JANUARY.

Day of Month.	Day of Week.	Day Lectures, 4 p.m. Subject.	Day Lectures, 4 p.m. Place of Delivery.	Evening Lectures, 8 p.m. Subject.	Evening Lectures, 8 p.m. Place of Delivery.
1	THURSDAY,			Opening Lect. Prof. of Physics, 1st part.	Theatre of Royal Dublin Society.
2	FRIDAY,			Opening Lect. Prof. of Physics, 1st part.	Theatre of Royal Dublin Society.
5	MONDAY,	1st Lect. on Geology, 2nd Part.	Theatre Museum of Irish Industry.	2nd Lecture on Physics.	"
6	TUESDAY,	2nd do.	"	3rd do.	"
7	WEDNESDAY,	3rd do.	"	4th do.	"
8	THURSDAY,	4th do.	"	5th do.	"
9	FRIDAY,	5th do.	"	6th do.	"
12	MONDAY,	6th do.	"	7th do.	"
13	TUESDAY,	7th do.	"	8th do.	"
14	WEDNESDAY,	8th do.	"	9th do.	"
15	THURSDAY,	9th do.	"	10th do.	"
16	FRIDAY,	10th do.	"	—	—
19	MONDAY,	11th do.	"	—	—
20	TUESDAY,	12th do.	"	—	—
21	WEDNESDAY,	13th do.	"	—	—
22	THURSDAY,	14th do.	"	—	—
23	FRIDAY,	15th do.	"	—	—
26	MONDAY,	16th do.	"	—	—
27	TUESDAY,	17th do.	"	—	—
28	WEDNESDAY,	18th do.	"	—	—
29	THURSDAY,	19th do.	"	—	—
30	FRIDAY,	20th do.	"		

FEBRUARY.

Day of Month.	Day of Week.	Day Lectures, 4 p.m. Subject.	Day Lectures, 4 p.m. Place of Delivery.	Evening Lectures, 8 p.m. Subject.	Evening Lectures, 8 p.m. Place of Delivery.
2	MONDAY, .	21st Lecture, Geology, 2nd Part.	Theatre Museum of Irish Industry.	11th Lecture on Physics.	Theatre of Royal Dublin Society.
3	TUESDAY, .	22nd do.	"	12th do.	"
4	WEDNESDAY,	23rd do.	"	13th do.	"
5	THURSDAY, .	24th do.	"	14th do.	"
6	FRIDAY, .	25th do.	"	15th do.	"
9	MONDAY, .	26th do.	"	16th do.	"
10	TUESDAY, .	27th do.	"	17th do.	"
11	WEDNESDAY,	28th do.	"	18th do.	"
12	THURSDAY, .	29th do.	"	19th do.	"
13	FRIDAY, .	30th do.	"	20th do.	"
16	MONDAY, .	Examination.	"	This month will be occupied with the evening instructions in Practical Chemistry in the Laboratory of the Museum of Irish Industry.	
17	TUESDAY, .	1st Lecture, Chemistry, 2nd Part.	"		
18	WEDNESDAY,	2nd do.	"		
19	THURSDAY, .	3rd do.	"		
20	FRIDAY, .	4th do.	"		
23	MONDAY, .	5th do.	"		
24	TUESDAY, .	6th do.	"		
25	WEDNESDAY,	7th do.	"		
26	THURSDAY, .	8th do.	"		
27	FRIDAY, .	9th do.	"		

MARCH.

Day of Month.	Day of Week.	Day Lectures, 4 p.m. Subject.	Day Lectures, 4 p.m. Place of Delivery.	Evening Lectures, 8 p.m. Subject.	Evening Lectures, 8 p.m. Place of Delivery.
2	MONDAY, .	10th Lecture, Chemistry, 2nd Part.	Theatre Museum of Irish Industry.	This month will be occupied with the evening instructions in Practical Chemistry in the Laboratory of the Museum of Irish Industry.	
3	TUESDAY, .	11th do.	,,		
4	WEDNESDAY,	12th do.	,,		
5	THURSDAY, .	13th do.	,,		
6	FRIDAY, .	14th do.	,,		
9	MONDAY, .	15th do.	,,		
10	TUESDAY, .	16th do.	,,		
11	WEDNESDAY,	17th do.	,,		
12	THURSDAY, .	18th do.	,,		
13	FRIDAY, .	19th do.	,,		
16	MONDAY, .	20th do.	,,		
17	TUESDAY, .	21st do.	,,		
18	WEDNESDAY,	22nd do.	,,		
19	THURSDAY, .	23rd do.	,,		
20	FRIDAY, .	24th do.	,,		
23	MONDAY, .	25th do.	,,		
24	TUESDAY, .	26th do.	,,		
25	WEDNESDAY,	27th do.	,,		
26	THURSDAY, .	28th do.	,,		
27	FRIDAY, .	29th do.	,,		
30	MONDAY, .	30th do.			
31	TUESDAY, .	Examination.			

APRIL.

Day of Month.	Day of Week.	Day Lectures, 4 p.m.		Evening Lectures, 8 p.m.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
1	Wednesday,	Easter recess till Monday, 13th April.	—	—	—
2	Thursday,		—	—	—
3	Friday,		—	—	—
6	Monday,		—	—	—
7	Tuesday,		—	—	—
8	Wednesday,		—	—	—
9	Thursday,		—	—	—
10	Friday,		—	—	—
13	Monday,	1st Lecture on Physics, 2nd Part.	Theatre Museum of Irish Industry.	—	—
14	Tuesday,	2nd do.	”	—	—
15	Wednesday,	3rd do.	”	—	—
16	Thursday,	4th do.	”	—	—
17	Friday,	5th do.	”	—	—
20	Monday,	6th do.	”	—	—
21	Tuesday,	7th do.	”	—	—
22	Wednesday,	8th do.	”	—	—
23	Thursday,	9th do.	”	—	—
24	Friday,	10th do.	”	—	—
27	Monday,	11th do.	”	—	—
28	Tuesday,	12th do.	”	—	—
29	Wednesday,	13th do.	”	—	—
30	Thursday,	14th do.	”	—	—

MAY.

Day of Month.	Day of Week.	Day Lectures, 4 p.m. Subject.	Day Lectures, 4 p.m. Place of Delivery.	Evening Lectures, 8 p.m. Subject.	Evening Lectures, 8 p.m. Place of Delivery.
1	FRIDAY, .	15th Lecture on Physics, 2nd Part.	Theatre Museum of Irish Industry.	—	—
4	MONDAY, .	16th do.	"	—	—
5	TUESDAY, .	17th do.	"	—	—
6	WEDNESDAY,	18th do.	"	{ Opening Lecture by Professor of Botany. }	Museum of Irish Industry.
7	THURSDAY, .	19th do.	"	2nd Lecture on Economic Botany.	"
8	FRIDAY, .	20th do.	"	3rd do.	"
11	MONDAY, .	Examination.	"	4th do.	"
12	TUESDAY, .	—	—	5th do.	"
13	WEDNESDAY,	—	—	6th do.	"
14	THURSDAY, .	1st Lecture on Botany.	Theatre of Royal Dublin Society.*	—	—
15	FRIDAY, .	2nd do.	"	—	—
18	MONDAY, .	3rd do.	"	—	—
19	TUESDAY, .	4th do.	"	—	—
20	WEDNESDAY,	5th do.	"	—	—
21	THURSDAY, .	6th do.	"	—	—
22	FRIDAY, .	7th do.	"	—	—
25	MONDAY, .	8th do.	"	—	—
26	TUESDAY, .	9th do.	"	—	—
27	WEDNESDAY,	10th do.	"	—	—
28	THURSDAY, .	11th do.	"	—	—
29	FRIDAY, .	12th do.	"		

* Of this course a portion may be delivered in the Botanic Garden, Glasnevin, as may be arranged by the Council of the Royal Dublin Society.

JUNE.

Day of Month.	Day of Week.	Day Lectures, 4 p.m. Subject.	Place of Delivery.
1	MONDAY, .	13th Lecture on Botany.	Theatre of Royal Dublin Society.
2	TUESDAY, .	14th do.	"
3	WEDNESDAY, .	15th do.	"
4	THURSDAY, .	16th do.	"
5	FRIDAY, .	17th do.	"
8	MONDAY, .	18th do.	"
9	TUESDAY, .	19th do.	"
10	WEDNESDAY,	20th do.	"
11	THURSDAY, .	21st do.	"
12	FRIDAY, .	22nd do.	"
15	MONDAY, .	23rd do.	"
16	TUESDAY, .	24th do.	"
17	WEDNESDAY, .	Examination.	"

GENERAL EXAMINATIONS.

General Examination	by the	Professor of Physics.
"	"	Professor of Chemistry.
"	"	Professor of Natural History.
"	"	Professor of Zoology.
"	"	Professor of Geology.
"	"	Professor of Practical Chemistry.

The prizes and certificates awarded at the several Examinations will be publicly conferred, and the Session closed with an Address by the Director, Sir Robert Kane.

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